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# The WELDING Journal

The Journal of the American Welding Society

# ARCOS ELECTRODE ANALYSIS AND COLOR CHART

| GRADE | Popular Name | Core Wire Type No. A.I.S.I. | Core Wire Type No. Arcos | Typical Analysis Cr. % | Ni. % | C. % | Others | Coating Type | Coating Color | Stub End Color End | Stub End Color Side | Diameter and Lengths | | | | Magnetic |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CHROMEND K | 19/9 | 308 | 308 | 19.0 | 9.0 | .07 | | Lime | Green | Yellow | | 9" | 14" | 14" | | No |
| STAINLEND K | 19/9 | 308 | 308 | 19.0 | 9.0 | .07 | | Titania | Brown | Yellow | | 9" | 14" | 14" | | No |
| CHROMANG | 19/9 Mn. | 307 | 307 | 19.0 | | .10 | Mn. 4.0% | Lime | Green | Black | | 9" | 14" | 18" | 24" | No |
| CHROMEND 19/9 Cb. | 19/9 Cb. | 347 | | | | | | | | | | 9" | 14" | | | No* |
| CHROMEND K Mo. | 18/12 Mo. | 31 | | | | | | | | | | 9" | 14" | | | No |
| STAINLEND K Mo. | 18/12 Mo. | 3 | | | | | | | | | | 9" | 14" | | | No |
| CHROMEND K Mo. Cb. | 18/12 Mo. Cb. | 31 | | | | | | | | | | 9" | 14" | | | No |
| CHROMEND 18/8 Mo. | 19/14 Mo. | 317 | | | | | | | | | | 10" | 15" | 15" | | No |
| CHROMEND KS | 18/8 Si. | 302 | | | | | | | | | | 9" | 15" | | | No |
| CHROMEND 16/7 | 17/7 | 30 | | | | | | | | | | 10" | 15" | | | No* |
| CHROMEND HC | 25/12 | 309 | | | | | | | | | | 9" | 14" | 14" | | No |
| STAINLEND HC | 25/12 | 309 | | | | | | | | | | 9" | 14" | 14" | | No |
| CHROMEND 25/12 Cb. | 25/12 Cb. | | | | | | | | | | | 9" | 14" | | | No* |
| CHROMEND HCN | 25/20 | 310 | | | | | | | | | | 9" | 14" | 14" | 18" | No |
| STAINLEND HCN | 25/20 | 310 | | | | | | | | | | 9" | 14" | 14" | 18" | No |
| CHROMEND 25/20 Cb. | 25/20 | 31 | | | | | | | | | | 9" | 14" | | | No |
| CHROMEND 25/20 Mo. | 25/20 | 310 | | | | | | | | | | 9" | 14" | | | No |
| CHROMEND HN | 17/25 | 311 | | | | | | | | | | 10" | 15" | 15" | | No |
| CHROMEND 8/18 | 8/18 | 325 | | | | | | | | | | 10" | 15" | | | No |
| CHROMEND 25/3 Mo. | 25/3 Mo. | 329 | | | | | | | | | | 10" | 15" | | | Yes |
| CHROMEND 29/9 | 29/9 | 312 | | | | | | | | | | 10" | 15" | 15" | | No* |
| CHROMEND 15/35 | 15/35 | 330 | | | | | | | | | | 9" | 14" | | | No |
| CHROMEND 13/60 | Nichrome | — | | | | | | | | | | 9" | 14" | | | No |
| CHROMEND 14/75 | Inconel | — | | | | | | | | | | 10" | 15" | | | No |
| CHROMEND 15/85 | Nichrome III | — | | | | | | | | | | 9" | 14" | | | No |
| CHROMEND 20/80 | Nichrome V | | | | | | | | | | | 10" | 15" | | | No |
| CHROMEND 2M | 2% Cr.-Mo. | | | | | | | | | | | 9" | 14" | 14" | | Yes |
| CHROMEND 2M(S) | 2% Cr.-Mo. | | | | | | | | | | | 9" | 14" | 14" | | Yes |
| CHROMEND 5M | 5% Cr.-Mo. | | | | | | | | | | | 9" | 14" | | | Yes |
| CHROMEND 12 | 12% Cr. | 4 | | | | | | | | | | 9" | 14" | 14" | | Yes |
| CHROMEND 16 | 16% Cr. | 43 | | | | | | | | | | 9" | 14" | | | Yes |
| CHROMEND 18 | 18% Cr. | 442 | 442 | | | | | | | | | 10" | 15" | | | Yes |
| CHROMEND 28 | 28% Cr. | 446 | 446 | | | | | | | | | 10" | 15" | | | Yes |
| MANGANEND 2M | Mn.-Mo. | — | 132 | | | | | | | | | 9" | 14" | 14" | | Yes |
| MANGANEND 2M(S) | Mn.-Mo. | — | 101 | | | | | | | | | | 14" | 14" | | Yes |
| MANGANEND 13 | 13% Mn. | — | 139 | Mn. 13 | | | | | | Orange | Red | 9" | 14" | 14" | | No |
| NICKELEND | Nickel | — | 210 | | | | | | Black | Black | Orange | 10" | 15" | | | No |
| MIXEND | Monel | — | 207 | For Mac | | | On Cast Iron | Special | Brown | Orange | Blue | 10" | 15" | | | No |
| REFORMEND | Mild Steel | — | 101 | For Strength Welds on Cast Iron | | | | " | Grey | Orange | | 9" | 14" | 14" | | Yes |
| CAREND | Armco Iron | — | 100 | For Sheet Metal Welding | | | | " | Black | | | 9" | 14" | | | Yes |
| BRONZEND E | Everdur | — | 910 | | | | Si. 3%, Mn. 1% Cu. 96% | " | Black | | | 9" | 14" | 14" | | No |
| BRONZEND P | Phosphor Bronze | — | 920 | | | | Sn. 5% Cu. 95% | " | Black | | | 9" | 14" | 14" | | No |

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W. SPRARAGEN, Editor

March 1944

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COVER

All Welded Tanker Tied Up to Welded Steel Dock. *Courtesy Alantic Refining Co.*

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# Erection and Welding Sequence as Applied to Welded Steel Hulls*

By Montgomery Q. Cellers†

AN ERECTION and welding sequence is a plan relating to successive operations of erection and welding required in the fabrication of any welded steel structures, and designed to accomplish certain definite results. It is not something mysterious but is common sense based on both theory and experience and can be determined before erection begins. It can very easily be mastered by anyone who has some knowledge of welding and steel construction.

The incorporation of an optional erection and welding sequence in the specifications by the designing naval architect would result in the elimination of most of the uncertainty of final results that has prevailed since the welding of steel vessels began, and I predict that it will not be long until this becomes common practice.

The reasons for an erection and welding sequence are:

1. Unless properly controlled, the shrinkage as a result of welding tends to produce unfair structures.
2. Shrinkage causes residual or locked-up stresses that sometimes result in fracture.
3. Shrinkage makes it difficult to control over-all dimensions.

While welding is the principal cause of warping, it is not altogether responsible. Among other causes are: (1) rolling and galvanizing stresses; (2) storage and handling distortions; (3) gas cutting shrinkage; (4) improper fitting, i.e., loose or forced fitting; (5) unequal expansion from sun's rays; (6) unequal expansion because of changes in atmospheric temperatures; and (7) overshrinking. *Overshrinking will sometimes destroy all that sequence may have accomplished.*

Aside from the necessity of having a fair shell below the water line for the sake of speed, an unfair shell above the water line and distorted or buckled bulkheads and decks need be straightened only for appearance and to provide a fair surface for foundations, etc. Loss of strength as a result of buckling in longitudinal bulkheads, or buckling of shell and decks near the fore or after end of a hull, need not be taken into consideration. Any of these conditions amidship must be considered, however, as it is the midship section of a hull that receives the most stress.

There is a tendency in most shipyards to spend time and money in straightening by shrinking and pressing rather than to adopt methods to keep structures straight while erecting and welding. I believe this is a mistake because it takes quite a large crew to do the straightening, and it consumes large quantities of gas and oxygen which in these times are essential materials. The use of water for quenching in shrinking operations is somewhat of a nuisance, especially on the hulls.

The belief that strict adherence to an erection and welding sequence may slow up fabrication is unfounded. Experience has proved that it ultimately speeds up production by eliminating most of the time and cost of straightening distorted members, and by saving time necessary to fit to the hull and fair-up unfair or warped assemblies.

An erection and welding sequence will also accomplish much beyond its general purpose. Where a yard is working more than one shift, it provides a method and order of procedure for each shift. If there are a dozen different ways of doing a job, and each shift tries to do it a different way, very little will be accomplished; while if each shift uses the same method and order of procedure, the job will be completed in an orderly manner with a minimum of man-hours. The objection to a sequence because of the fact that ships' hulls and their various parts cannot be fabricated and erected by a sequence governing every operation down to the smallest detail is no objection. This is because an erection and welding sequence can be more or less general and need go into detail in very few instances. The more knowledge the shipfitters and welders have of just what welding shrinkage is and how it affects the ship's hull and its many subassemblies and the various methods that are used to control or counteract that shrinkage, the less detail the sequence need have.

There has been much discussion pro and con regarding welding under restraint versus so-called "stress-free" welding. I prefer the "stress-free" method because by its use we can eliminate much stress which, if not eliminated, may prove disastrous. The hulls produced through welding entirely under restraint have considerable locked-up or opposing stresses in them which may result in fracture later if too much of this stress is in a part of the hull that receives considerable stress in use. A restrained weld will relieve itself of some contraction while in a plastic state, but there is considerable contraction that must take place after the weld metal cools beyond the plastic stage.

There are objections to using some of the present type of automatic welding on shell and main decks in other than subassembly. While the high heat, speed of welding and the large amount of flux covering the weld result in an annealed weld, the objection is that there is considerable contraction parallel to the weld and consequently automatic welding is not as flexible as manual welding nor as easy to apply to "stress-free" welding. If automatic welding is done under restraint, there is considerably more locked-up stress than if manual welding were used under the same conditions.

While the only "stress-free" welded structure is a properly annealed one, a structure produced by "stress-

* A lecture given before the Los Angeles Section, A.W.S., September 16, 1943.
† Welding Superintendent, Seattle-Tacoma Shipbuilding Corporation, Seattle, Wash., Chairman of the Puget Sound Section of the AMERICAN WELDING SOCIETY.

free" welding should have little more locked-up stress than a riveted one and considerably more strength than a riveted structure because of the higher strength of welded joints. Riveting sets up stress because of the expansion of the metal around the rivet holes.

It might be well here to briefly discuss the things that go to make up an erection and welding sequence. They are: (1) welding technique, (2) welding procedure, (3) order of welding, (4) manner of erection and (5) order of erection.

*Welding technique and procedure are as much a part of erection and welding sequence as are manner and order of erection and manner and order of welding. While it is possible to accomplish some results without controlling them, far greater results can be accomplished by their control.*

For the purpose of this article, we will give our interpretation of the meaning of welding technique and welding procedure. The other three are self-explanatory.

Welding technique pertains to such things as welding heat (amperage and voltage control), angle of electrode to the work, arc length, speed of travel and oscillation.

Procedure relates to size of pass, number of passes and the order of making them, back step or wandering procedure, direction of welding, etc.

As most experienced welders have some knowledge of welding technique and precedure control, we will not attempt to go into them in detail.

All of you who are familiar with some of the problems encountered in fabricating all-welded steel structures are possibly not aware that the *methods and order of erection are just as important as the methods and order of welding and coordination of the two is necessary to accomplish the desired results.* Because of these facts, it is best to think of erection and welding not as two unrelated jobs, but as one job, which can be outlined and treated in a general sequence of operations. Later on as we apply erection and welding sequence to various subassemblies, you will readily see the importance of manner and order of erection, and its relation to manner and order of welding.

## A Study of Expansion and Contraction of Metal in Relation to Welding

Metal expands under heat and contracts as it cools. If the expansion is restrained, the heated metal will upset to some extent (depending upon the amount of heat and to what extent the member is restrained) which results in more shrinkage than would be the case if expansion were not restrained. Now if contraction were also restrained, we would have what we call residual, or locked-up stress. The explanation of the accompanying illustrations will prove the above statements.

Figure 1 is an angle bar before and after one pass is welded along one flange. The result is considerable warpage due to the longitudinal contraction of the weld metal.

Figure 2 shows two 15-lb. plates beveled 30° with a $^1/_8$-in. root opening. After tacking and before welding, witness marks are placed by making punch marks on either side of the weld 10 in. apart. After welding and cooling we find a shrinkage of approximately 0.055 in. The metal when deposited in the "V" was in the fluid state; therefore it was expanded to the limit, and as it was contracted, it drew the plates toward one another.

In order that you may better understand what is meant by residual stress, we are going to show you the results produced by disregarding erection and welding sequence and also what can be accomplished through the proper use of it. By disregarding it, we get locked-up stress and warping. Through the application of it, we overcome these faults. As we go along, we are going to discover a few simple rules which you must remember, because they will be applied later on in developing erection and welding sequence as structures demand.

In Fig. 3 two members were welded while both were entirely restrained. The result was that the butt weld fractured because of the contraction of the weld metal. If these members had been properly welded, the weld would probably have withstood the strain. However, as we wished to show you the results produced through

Fig. 1

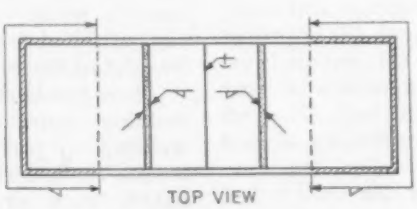

Fig. 3

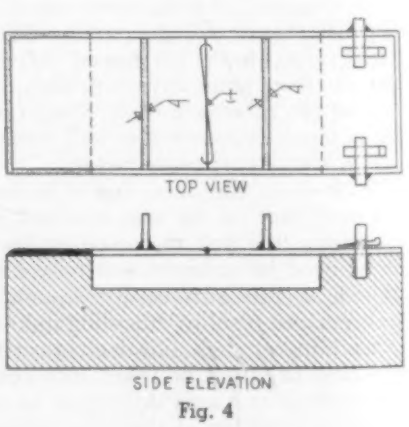

Fig. 4

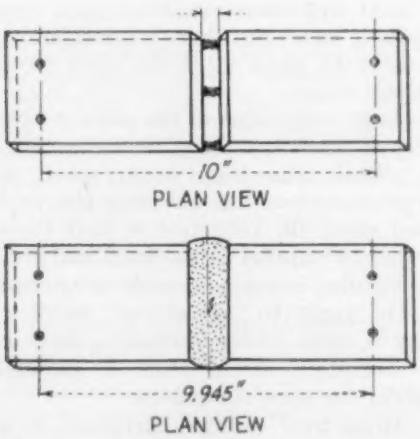

Fig. 2

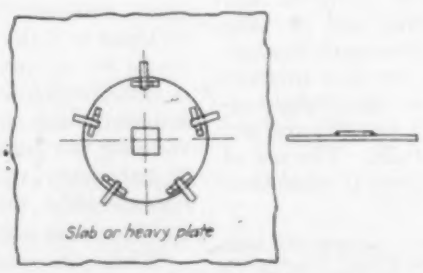

Fig. 6

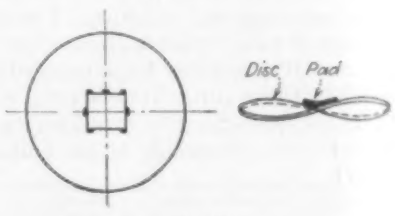

Fig. 5

restraint of contraction, we welded each plate to the strongback and then ran one light pass down the joint before welding the two bars on either side of the joint, and consequently the butt weld was not strong enough to withstand the strain of contraction. Had it withstood the strain, there would have been considerable locked-up stress in the members between the strongbacks to which they were welded.

We will take the same materials used in Fig. 3 and weld one bar to one end of the strongback, making it immovable, while we clamp and wedge the other bar to the opposite end of the strongback, allowing it some freedom of movement as shown in Fig. 4.

After welding the butt and the two bars, we find that the weld did not break because one bar was not totally prevented from contracting toward the point of welding. After removing the wedges we find the bar is straight. This is the result of restraint afforded by clamping. The other end of the bar can now be welded to the strongback and the job is complete with a minimum of locked-up stress.

We now have Rule One, to wit: Leave one end of a member or structure free to contact toward the point of welding. We learn here, too, the *importance of method of erection*. Had both bars been tacked or welded instead of being clamped, either tacks or welds would have broken, or there would have been residual stress in the member because of the stiffness of the strongback.

Figure 5 shows a disk with a pad welded to it near the center. If this job were welded without being clamped down, the result would be considerable warpage.

Figure 6 shows how this job can be clamped and welded without warpage. We now have Rule Two, which is: Warpage may be prevented through partial restraint by clamping or weighting the members down.

Figure 7 represents a pipe which is to be welded in a collar which, in turn, is to be welded to a bulkhead. The result of disregarding welding sequence in this case cannot be clearly demonstrated except by actual test, because to do so we would have to have a large bulkhead held rigidly in place and the welding must be done with oxyacetylene. By doing this job with arc welding the locked-up stress would possibly not be great enough to break the weld. If we were to weld the collar to the bulkhead, then the collar to the pipe, in that order, there would be considerable locked-up stress in the welds. This was demonstrated to me several years ago when it was tried to weld, in the above order, with oxyacetylene, a pipe and collar to a large rectangular tank.

By welding in the above order, we locked up all the stress possible in the plating and the weld of the pipe to the collar fractured. Had we clamped the collar to the bulkhead while the pipe was being welded to it (as shown in Fig. 7), allowed it to cool and consequently contract, then welded the collar to the bulkhead, we would have had the locked-up stress of only one weld.

In order that we may learn how residual stress affects the longitudinal strength of a hull, we will theoretically apply an example of it to a hull.

Figure 8 represents a subassembled section of a main deck.

We will give no dimensions, weights of plating, nor will we show any deck framing because we are dealing only with the longitudinal strength of the deck plating.

The result of erecting and welding this assembly with complete disregard for sequence is alternate compression and tension areas. The compression areas are marked *C* and the tension areas are marked *T*.

By way of illustration we will erect and weld this subassembly so as to lock up all the longitudinal stress possible. We are not greatly concerned about transverse stress because the hull of a ship rarely, if ever, receives as much transverse as longitudinal stress. If it becomes a choice of transverse or longitudinal stress, we try to eliminate or avoid the longitudinal stress.

We get longitudinal stress from transverse welds and transverse stress from longitudinal welds when welding is done manually.

We will erect and tack the longitudinal seams first and, second, the transverse seams. If we do the welding without regard to procedure, after the welding is finished and the plating cooled to atmospheric temperature, we have tension in the transverse welds and longitudinal compression across the plating opposite the transverse welds. It is obvious that such disregard of procedure control greatly impairs the longitudinal strength of this subassembly. If this section were then erected on the hull and tacked securely in place (including deck to shell junctures) and other sections erected on either end and secured in the same manner, then the transverse bulkheads and the butts between sections welded, there would be so much locked-up stress that the completed ship would lack the longitudinal strength the designing architect believed was necessary to enable the vessel to withstand the stresses that would be encountered in the intended service.

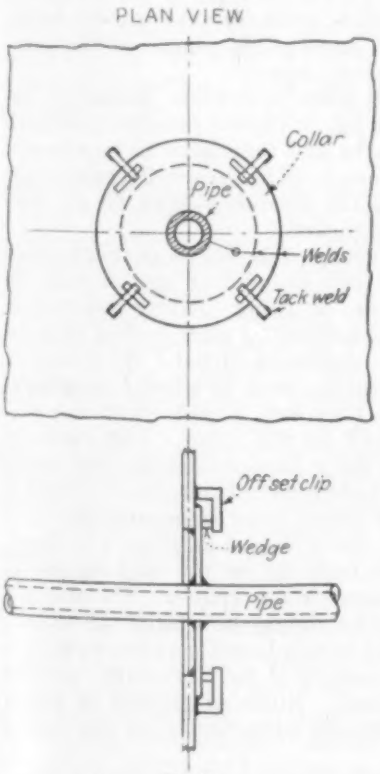

Fig. 7

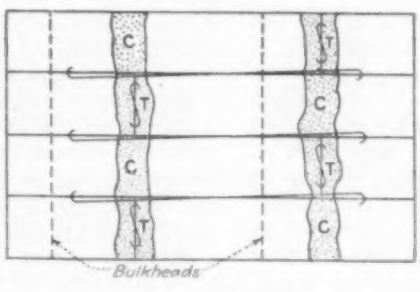

Fig. 8

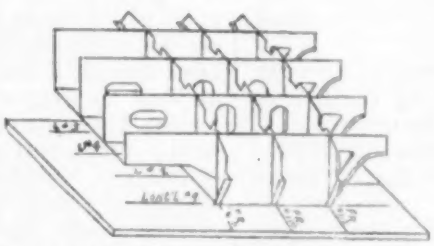
Fig. 9—Reduction Gear Foundation—a Subassembly of Deep Framing

## Method of Controlling Residual Stresses and Fabricating Fair Structures

Before we take up the erection and welding of a ship's hull, we will discuss generally some of the methods and equipment used to avoid or control residual stress and fabricate fair structures. The use of these methods and equipment is not limited to welded steel ship construction but can be applied to other types of welded construction.

An erection and welding sequence begins in the mold loft. Because welding causes shrinkage, provision must be made for extra material to compensate for this shrinkage. This is done by expanding the templates, which means the templates are made larger than the finished structure or assembly is intended to be. Some yards use two sets of templates, an expanded template for use before welding and a normal template for use after welding. In addition to the extra material gained through the use of an expanded template, excess material must be left wherever necessary to have enough for trimming to size after welding and to provide for enough extra length for fitting on the ship where definite dimensions cannot always be maintained.

The amount of expansion necessary is determined by using a shrinkage chart which has been compiled by checking shrinkage on numerous structures welded with all types and sizes of welds. It would not be practical to apply this chart in figuring the shrinkage expected in every member and assembly which go to make up the hull. Instead, the length of the hull is divided into sections according to the general weight of material and the amount of welding in each section.

It is not necessary for the welders and shipfitters to know how much shrinkage is going to take place in a member or assembly, but they must know that it is going to shrink, and provide for controlling that shrinkage, so that locked-up stress in the finished job is not excessive and the structure or assembly is fair. Among the many things that govern the amount of weld shrinkage are: (1) amount of heat the welder uses for a given size weld and a given size rod, (2) speed of welding, (3) root opening, (4) weld size, and (5) welding procedure.

One of the most important things which affect the fairness of a finished welded structure or assembly is weld size. Oversize welds tend to shrink a member more than welds of normal size. Shrinkage is in proportion to the excessive weld metal. The architect has computed the necessary joint strength and specified weld sizes to meet the requirements. In addition to the problem of having to contend with excessive contraction from oversize welds, more time and material are consumed in making them. The slower the actual operation of consuming a welding rod into the weld, the more the warpage. The wider the root opening, the more shrinkage. The use of "hot" rods gives less warpage because the high speed of welding with this type of electrode imparts less detrimental heat into the parent metal than do the slower electrodes. If it were possible to make a complete welded joint instantaneously there would be very little distortion or locked-up stress in the joint, provided contraction was in no way restrained. Such a desirable condition is not possible with the present-day welding equipment.

The major shrinkage of a manual weld is at right angles to the weld. The shrinkage along the line of weld is so slight that in most cases it can be ignored.

Some of the ways in which welding shrinkage is controlled or counteracted are: (1) care in fitting, (2) use of the wandering procedure, (3) backstep procedure, (4) partial restraint while welding, (5) keeping the welding evenly balanced both vertically and horizontally, (6) peening, (7) preheating, (8) postheat treatment (annealing) and (9) erection by subassembly. Following is a brief explanation of each of these methods.

### *Care in Fitting*

If the fitting is sloppy, i.e., if the root opening of edge to edge butts is not uniform, but varies in width throughout its length, if lap joints are not fitted metal to metal, if force is necessary to secure a proper fit, or if the proper order of fitting in relation to the order of welding is not maintained, then the purpose of a welding sequence is defeated before welding begins.

### *Use of the Wandering Procedure*

The wandering procedure is the running of short increments at random throughout the structure. This spreads the heat over the entire unit or assembly and keeps the heat lower generally throughout the structure. Before the second series of increments are started the first will have cooled. The metal upsets when heated by the arc and is stretched while cooling (but still in a plastic stage) because of the stiffness of the surrounding metal. This method cuts shrinkage considerably

### *Backstep Procedure*

Backstep means welding short increments in the opposite direction to which welding is progressing and thoroughly fusing each increment into the start of the preceding one. This method distributes a near equal amount of stress in each increment.

### *Partial Restraint While Welding*

Many sorts of jigs, clamps and other restraining devices are used to hold members to shape while welding. Strongbacks are used to a great extent, especially on shell and other plating butts. These restraining devices must not prevent shrinkage toward the point of welding, but should act as a guide only for the member while it is shrinking. Generally, in restraining members to hold them straight while welding, it is necessary to lock up some stress. This is all right if the locked-up stress is not great enough to cause fracture or is not where a great amount of extra stress will be placed on the members having such locked-up stress.

Sometimes tacking is used to restrain shrinkage but is not as satisfactory as jigs or clamps because shrinkage generally breaks the tacks and they have to be renewed before welding is continued. This generally entails the use of clamps to bring the assembly down to the slab again before it can be retacked.

Strongbacks or temporary stiffening is generally used on butt welds but may also be used on and around the edges of bulkhead, deck or other plating assemblies. Strongbacks should be clamped in place rather than be tacked so as to allow shrinkage toward the point of welding. In some instances, such as when strongbacks are used on butt welds, they may be tacked on one side of the weld and clamped on the other. One common mistake often made in using strongbacks on butt welds is in making them too short to be fully effective. Plating butts which are welded before other structural members are added should have strongbacks at least 3 ft. long. Deck and shell butt strongbacks on the ship should be at least as long as three frame spaces. On straight plating butts strongbacks should be placed across the weld. When butt welds form a knuckle at the weld, and restraint of shrinkage inward is not necessary, parallel strongbacks may be used. Butts in shaped or rolled plating should have shaped strongbacks on the inside of the bend.

Sometimes it is necessary to back-set or warp a mem-

ber in the opposite direction to which it will shrink when welded. An example of this is when welding rider bars to plate webs which must be true because of other members attaching to them or when they may be used for machinery bases.

*Keeping the Welding Evenly Balanced Both Vertically and Horizontally (See Fig. 9)*

Welding should be kept evenly balanced when welding long subassemblies. This is not altogether true of those having a more bulky shape. When welding junctures of framing, welding should progress evenly in regard to all welds of each juncture and should be distributed evenly from top to bottom. The distribution of heat is not so important on junctures of deep framing with respect to holding the shape of the assembly.

Long members or long subassemblies can only be kept straight by having the welding progress evenly from side to side and top to bottom and, in some cases, side or up or down movement must be restrained. This is the case where more welding is required on one side than there is on the opposite side. Identical members may be clamped back to back. Here again, if the amount of welding required is not even side to side or top to bottom, some additional methods may have to be used. This may be done by warping or springing the member in the opposite way to which it is expected to warp. In welding long subassemblies, the wandering sequence may be used or welding may start in the center and progress toward either end, or may start at one end and progress toward the other end, depending upon whether it is desired to shrink the assembly as a whole or to shrink each part of it as welding progresses.

*Peening*

Peening as a method of stress relieving is sometimes resorted to when it cannot be accomplished by ordinary means. This is especially true in welding heavier materials where all the weld shrinkage is locked up. The amount of peening necessary is often a matter of conjecture. If the member is heavy enough to stand heavy peening and no large diameter rod with plenty of heat is being used, then the weld may be peened until it flakes the metal on the surface. Sometimes light peening with a peen hammer is all that is necessary. In only rare cases is the last pass of multiple pass welds peened.

*Preheating*

Partial or complete preheating is sometimes used when welding subassemblies or parts of subassemblies made up of heavier shapes or plates. Partial preheating may be done with gas, oil torches or other means, and complete heating with furnace or "hot house." The principle of preheating lies in bringing the temperature of the parent metal nearer that of the weld metal. The degree of effectiveness depends on the amount of heat used. If the temperature of the member or assembly is near 1200° F. (at which heat the metal is plastic) while welding is in progress and the finished job allowed to cool slowly, there would be no stress in the finished job. Such a desirable condition is only possible in oxyacetylene welding, so in order to produce a stress-free arc-welded member or assembly, we must stress relieve it through annealing.

*Postheat Treatment (Annealing)*

Annealing is a quick process of aging. Through its use we accomplish in a few hours that which would take years to accomplish through aging at atmospheric temperature. It has been conceded that a grey iron automobile motor block casting takes two years of aging to relieve itself of casting stresses in order that machining may be done without the block warping while in the process of being machined or after machining has been completed. It should take considerably less time than that to relieve a welded steel hull of stress because the hull "works" while under way in a sea and also from the expansion and contraction of the decks and upper shell from the changes in atmospheric temperature.

Partial annealing may be used if the shape and size of the member permits. Complete annealing is accomplished through the use of a furnace with controlled heat. If the job is heated too fast, the lighter members will absorb the heat before the heavier members, thereby setting up additional stress that might result in distortion or fracture. Therefore, the heat is raised slowly to about 1175° or 1200° F. and held there for several hours. At that temperature the metal is plastic and any stresses set up by expansion or contraction from the welding heat will be relieved. After the desired "soaking" time has expired, the heat must be lowered and the job allowed to cool slowly to atmospheric temperature because the heat will leave the lighter members before it leaves the heavier, resulting in strain and thereby defeating the purpose of the annealing process. Complete stress relieving is generally used only on those members which will be subject to severe strain or shock, such as gun foundations, engine bases, rudders, rubber bearing weldments, etc.

*Erection by Subassembly*

The construction of a hull on the ways, piece by piece, would constitute quite a problem from the standpoint of controlling contraction and residual stresses. We overcome this problem to a great extent by prefabricating subassemblies. These subassemblies are also made up of prefabricated parts which contract when welded and consequently this contraction does not affect the subassembly. The same holds true with relation to the subassembly and the hull. Subassemblies may include rudder bearing weldments, flat and vertical keels, skeg and keel assemblies, shell sections, superstructures, bow and stern, and foundations such as gun, reduction gear, turbine and many small units. If design permits, sections of the ship from flat keel to main deck may be included.

Perhaps the most important consideration in subassembling is a sturdy foundation upon which to erect the structure. It should be strong and solid enough to hold the subassembly firmly in place and not get out of shape through constant use. Subassemblies may be erected in any position, resting them preferably on the flat surface having the largest area or on the surface which provides the most solid foundation. In fitting and welding these subassemblies, the main thing to bear in mind is that they should be tacked and/or clamped together and to their cradles in such a manner as to provide as little restraint as possible to contraction.

The best type of slab for subassembling is one of plating or cast iron slotted for use of pin dogs. These slots may be as close as their width apart. Care must be taken when using this sort of assembly slab that the dogs are not jarred loose in the handling of material, hammering or contraction of the assembly upon which welding is being done. This type of slab is more suitable, too, when weights are used to prevent buckling of plating while welding. These weights may be in the form of boxes filled with slugs or punchings with suitable foot pieces which bear firmly on one or more sides of beams, stiffeners or butt welds. Open-beam platforms are satisfactory when welding heavy material on which weight boxes or edge restraining are not necessary. The beams should be placed fairly close together. Another advantage a heavy slab has over open-beam platforms

is that the slab absorbs considerable heat and therefore helps prevent shrinkage.

Cradles or special jigs are practical when fabricating assemblies having other than flat surfaces and where much duplication is necessary. It is not an easy matter to design such jigs or cradles so as to use weights effectively on assemblies having other than flat surfaces; however, buckling is less noticeable in curved surfaces than it is in flat ones.

The use of these and other methods not mentioned can vary from yard to yard in their application to various types of steel construction. The important thing is application of the correct method to follow in working out a sequence for each type of construction by tailor-making the procedure to fit the job.

We will now explain erection and welding sequence as applied to some of the many subassemblies of a ship's hull.

## Flat and Vertical Keels

Flat and vertical keels present a fairly simple job of subassembly. Keel brackets may be welded to center vertical keel first because shrinkage of center vertical keel is greater than that of flat keel. If transverse frame and bulkhead brackets are left unwelded in subassembly and welded in sequence on the hull, there will be more even contraction of the hull longitudinally. Welding of brackets to both flat and vertical keels must be kept evenly balanced and the heat must be distributed evenly from top to bottom of center vertical keel to maintain alignment. Welding of brackets to flat keel must follow fitting within four or five frame spaces because of the shrinkage of the flat keel while welding is in progress. If the center vertical keel is to be welded to the flat, they must not be tacked together beyond an unwelded bracket. It is generally necessary to warp or bow an all-welded keel down to offset unequal contraction between bottom and top of the keel subassembly. (See Fig. 10).

## Bulkheads and Deck Subassemblies

The simpler designs of bulkheads offer a fairly easy problem in fabrication and welding sequence. (See Figs. 11 to 13.)

First we will consider a bulkhead whose plating is under 10 lb. and whose stiffening runs in one direction and is all on one side of the bulkhead. It is necessary to erect the bulkhead on a slab or platform so as to be able to weight down the plating to prevent buckling while welding, and to maintain a flat surface generally of the entire bulkhead plating.

We start erection by fitting and welding all plate butts. In fitting and tacking these butts, which should first be cut to fair lines, it is necessary to maintain a root opening of approximately $^1/_8$ in. so as to get proper penetration. Spacers of the desired thickness may be placed between the plates and sufficient tacking done to keep the seam fair until the first pass is completed. Weights which straddle the seam and bear within about 3 or 4 in. of either side of the seam are preferable and are used to prevent the welding heat from distorting the plates. The first pass is placed by running increments of 6 to 12 in. in length spaced about 18 to 30-in. centers; the next series of increments may be run between or behind the first series, etc., until the first pass is completed. After all welding on this side is completed, the plate is

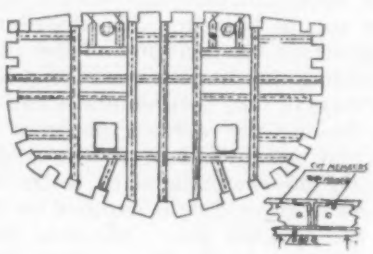

Fig. 13

turned over and the opposite side of the seam is chipped out to sound metal and the welding completed in a manner similar to that used on the first side. The long seams are then fitted and welded in a similar manner.

After welding of the plating is completed, it is laid out with an expanded template and the stiffeners tacked in place. Weight boxes similar to those used on the plating seams are used while welding the stiffeners to the plating, and the edges of the plating are clamped to the slab in such a manner as not to restrain contraction. Welding is carried out using the wandering sequence, welding one or more stiffeners at a time, distributing the heat the entire length of each stiffener and staggering the increments from side to side.

In welding stiffening to a bulkhead where stiffeners are vertical and horizontal, welding must be started in the approximate center and advance toward the outside in all directions. The junctures of the stiffeners must be welded in advance of the stiffeners to the plating because of the unequal contraction of stiffeners and plating. The rigidity of the plating will restrain contraction of the stiffener joints and leave tension in them when being welded which will force more contraction in the plating when the stiffeners are welded to it, thus resulting in nearly equal contraction of both.

Bulkheads having stiffening on both sides may require a special cradle or blocking for fitting and welding the stiffeners on the second site. Expected contraction of the bulkhead from welding these additional stiffeners must be provided for by accordingly expanding the template that is to be used for trimming.

If the weight of the plating in the bulkhead is over 10 lb. it may not be necessary to use weight boxes while welding. Beveling must be resorted to in preparing

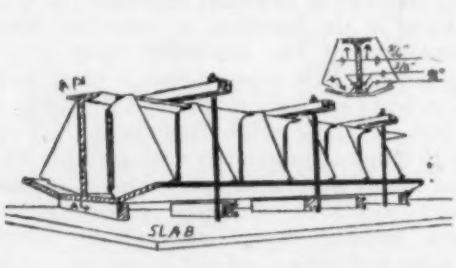


Fig. 10

Fig. 11

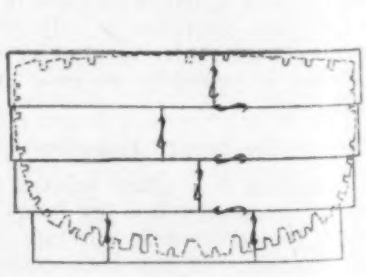

Fig. 12

All-Welded Flat and Vertical Keel Subassembly, Showing Method of Springing Offset Contraction of the Flat Keel

butts in heavier plating. Trimming of subassemblies should be done as far as practicable after welding is completed.

Deck sections are subassembled similar to bulkheads except that those having camber or sheer, or both, must be erected on cradles having the same camber or sheer.

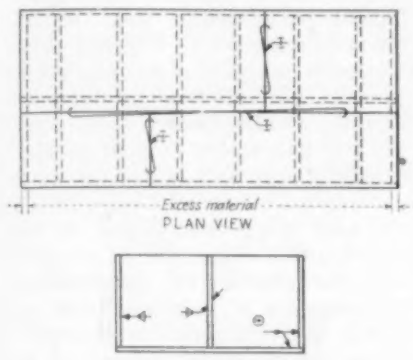


Fig. 14

## Subassembly of a Double Bottom or Platform, Floors and Bulkheads

Figure 14 represents a tank top or platform, three longitudinal bulkheads, and six floors under the platform, of which all members are 7-lb. plate. This makes a very convenient subassembly. We will start this job in the mold loft and follow it until ready to erect on the ship.

The loftsman knows that the members in this assembly are going to shrink when welded, so in order to have the proper dimensions in the completed assembly, he will have to make oversize or "expanded" templates and leave excess material in the proper places. He has a weld shrinkage chart which gives the approximate shrinkage in different weight members for each type of welded joint.

The tank top plating does not need to be expanded to compensate for shrinkage of the butt welds but may have excess material on one side and one end. Frame lines must be laid out with expanded templates because when the center line bulkhead and floors are welded to the tank top, it will shrink approximately 0.055 in. for each "tee" weld. The center line bulkhead will shrink approximately double that amount because it has two "tee" welds per frame space and must be expanded accordingly. The floors will contract slightly toward the tank top and the center line bulkhead, so excess material on the bottom and outboard edges is necessary.

When we erect and weld this assembly we must start with fitting of the transverse butts of the tank top, welding both of them before the long seam is fitted or tacked. If we weld the long seam before the transverse seams, we will have longitudinal shrinkage at the transverse seams and none in the plating directly across the long seam. This will result in considerable buckling of the plates opposite the transverse weld. It is necessary to use weight boxes which straddle the seam while welding is in progress in order to hold to a minimum buckling of the plates. The assembly from this point on can be most conveniently done in an upside-down position.

In erecting the floors and longitudinal bulkheads to the tank top, we must tack the floors to the longitudinal bulkheads and clamp both to the tank top because the longitudinal bulkheads are going to contract longitudinally more than the tank top, and the floors and longitudinal bulkheads outboard are going to shrink toward the centerline bulkhead. Tacking of each pair of floors and the section of longitudinal bulkheads between floors to the tank top should be done only when reached in the sequence of welding. It is best to weld the floors to the longitudinal bulkheads first allowing them to shrink longitudinally, then weld all to the tank by starting near the center of the assembly, welding two opposite floors to the tank top, then the longitudinal bulkheads to the tank top either way from the welded floor to the next unwelded floor, etc., until the welding is completed. While welding is in progress the tank top may be clamped to the slab by clips or dogs placed around the edges. Weight boxes on the plating between the floors will prevent buckling of the tank top. If plating is fairly heavy, weight boxes will not be necessary.

After welding is completed, the bottom and outboard edges of the floors and all sides of the tank top are laid out with a normal template and cut to size except that excess material may be left on one or both ends of tank top and longitudinal bulkheads. All water lines and butt lines and any necessary reference lines must be scribed in for the convenience of the shipfitters when this assembly is erected on the hull. In order to maintain a hull of fair lines these butt, water and frame lines must be maintained throughout its construction.

## Subassembly of Bow

Welding of the framing of bow subassemblies must be kept evenly balanced port and starboard. This is especially true of sharp, narrow bows. The framing junctures may be completely tacked and welded first or they may be welded simultaneously with the framing to the shell. Unless the design is such that shell butts can be welded as they are reached in the sequence of welding, the shell may be clamped to the framing and the shell butts welded before the framing to the shell.

If the bow is so narrow as to have areas which cannot be welded from the inside, it is best to weld both port and starboard shell in this area from the outside. In this case the use of erection bars welded to the framing and plug or slot welds is the preferable type of construction. If outside welding from one side only is permitted in the inaccessible area, then a strongback or beam tacked or clamped to the stem bar is necessary to maintain alignment.

## Subassembly of Stern

If the rudder bearing is incorporated in a weldment, the weldment (after annealing) can be placed in a jig or cradle and the remainder of the stern erected to it. As contraction has already taken place in the weldment, this must be taken into consideration. If design permits, all structures forward and aft and on either side of the weldment should be shrunk toward the weldment. These sections may or may not include shell. It may be possible to weld and shrink them before welding to the weldment, which is especially true if there are longitidunal bulkheads running the full length of the assembly off the center line and the transverse members butt weld to them. The fore and aft section should be welded to the weldment before the side sections, and the side sections should be welded to the weldment simultaneously, in order to obtain constant equal shrinkage toward the weldment.

The wandering sequence generally is the preferable procedure in fabricating bow and stern subassemblies. It is not necessary to provide for relief of locked-up

stress around the stern shell and framing as the shape of the structure takes care of that.

We have discussed the use of erection and welding sequence as applied to the principal subassemblies which make up the hull structure. These same principles of erection and welding sequence will be used in erecting and welding these subassemblies into a relatively stress-free hull.

## Erection and Welding of the Hull of Vessels of Longitudinal Construction

In order to hold the lines of a hull within the specified tolerances, it is necessary to establish certain reference points and lines by which constant checking can be done. Points should be established on the ways for checking the position of the keel, deck heights and the various butt and water lines. All subassemblies and each part going into the hull structure should have all lines necessary, such as butt, water, frame or other reference lines to maintain the lines of the hull during construction. These lines should be re-established, after welding has been completed beyond them, to be used as reference for further erection or setting of machinery, etc.

All members should come to the ways with excess material on one or both ends. It is generally necessary to have it on one end only, in which case it should be on the forward end forward of midship and on the after end aft of midship.

The pounding and pulling necessary to get shell plates, longitudinals, bulkheads, etc., into place would move the structure were it not held securely in place. This is done by anchoring the keel to prevent rise, side or for and aft movement, and by shoring and cribbing the bottom shell outboard, and shoring the upper shell.

The erection of a hull of longitudinal construction starts with the placing of keel assemblies. The keel is the backbone of the hull and is designed for strength. Therefore, the junctures of the various sections of subassembled keel should be welded together on the keel blocks in such a manner as to obtain a stress-free joint.

The bottom shell is erected and the butts welded from midship both ways as far as there is no danger of contraction being restrained too greatly. This is generally limited to the midship one-third of the hull. The shell plate long seams (if they are lapped) can be bolted to hold them in line fore and aft, but not so tight as to restrain contraction. If these seams are butted, they must be strongbacked sufficiently to hold them fair. Next, longitudinals, transverses and bulkheads are erected. Because we have the same situation of unequal contraction between shell and longitudinal members as we have between the flat and vertical keels, we cannot tack the longitudinals to the shell; to do so would lock up stress in these members by preventing them from shrinking toward the point of welding.

We must impress upon you at this time that throughout the construction and welding of the hull, all possible precautions must be taken to prevent restraint of longitudinal contraction toward the point of welding. The control of transverse contraction is not so important as longitudinal because of the difference between length and width of the ship; however, all stress must be avoided or eliminated where possible to a degree that will insure against weld fracture during construction or failure in service.

To obtain minimum transverse stress in both the transverses and the shell plates, the plates are shrunk transversely by welding the longitudinals to them before tacking and welding the transverses to the shell. Welding of the transverses to the shell and longitudinals shrinks both in a longitudinal direction. The transverses must be clamped to the shell until they are tacked or welded to it.

The bottom shell and framing are generally welded before the upper shell and framing because it facilitates erection. The band welding method is generally used, although welding can be carried out strake by strake, if the shell laps are permitted to "float" until longitudinal contraction has taken place. Welding should start at a bulkhead nearest midship and progress fore and aft from that point. The bulkhead is welded to the shell and longitudinals which shrinks these members longitudinally. If the longitudinals weld to the shell, they will now be welded fore and aft as far as the next unwelded transverse. This shrinks each shell plate transversely in the area being welded and the strakes crawl away from one another a fraction of an inch at the lap, depending on the number of longitudinals on each strake. This operation is continued until subassembled sections of shell and framing are reached. In all of these operations the wandering procedure may be used for each welding step.

The upper shell framing and main deck are welded in a similar manner to that used in welding the bottom shell and framing, except that more precautions should be exercised regarding restraint of longitudinal contraction, because the higher the contraction is above the keel, the more it is apt to raise the keel. Very seldom is any difficulty of keel rise encountered in the midship section.

Shell fittings such as scoops, sea chests, struts, etc., may be erected and welded after welding of the hull has progressed beyond them, facilitating erection. Resulting locked-up stress in the welding of these members can be eliminated to a great extent by peening.

Any subassemblies which include plating and framing, or sections of either, should have entire master butts tacked and welded simultaneously. If there is any keel rise as welding of the hull progresses fore and aft, the rise may be prevented by changing from band welding to an angle forward in relation to the keel, i.e., welding on each strake will be one or more frame spaces in advance of the next strake below. This angle of progress may be altered as required. It may be necessary to increase the angle of progress as welding nears the ends of the hull. This is particularly true regarding the forward end. By inclining the angle of progress of welding too much, it is possible to bring enough downward pressure of the hull on the keel blocks at the point of welding to have a hogging effect a short distance toward midship. Some engineers contend it is better to have a fraction of an inch rise than to have the keel hold its proper heights. This may be true. However, a keel rise is proof of locked-up stress, which, if close enough to midship, will affect the strength of the hull.

As the decks are reached in the process of erection and welding, they are treated as any other longitudinal member. However, as they are a little more complicated than a one-piece longitudinal member, we will give you a more detailed sequence.

If at all possible, it is best to subassemble sections of the superstructure with the main deck subassemblies. If this is done, the contraction caused by welding superstructures to the decks will not affect the hull generally.

The deck should not be welded to the shell until contraction has taken place in both. As it is not always possible to get final contraction of deck sections before they are erected on the hull, they must be clamped to the shell, transverses and any longitudinal members under them that are not subassembled with them because, as contraction from welding takes place, the end of the section to which welding is progressing must be free to contract toward the point of welding. The decks

may be welded ahead or may be welded with or behind the shell and shell framing. When the ends of deck or platform sections are welded together, to make-up plates or to bulkheads, both plating and framing should be welded simultaneously and plating butts must be strong-backed. The wandering sequence should be used when joining sections of deck together.

If the ship is designed with complete transverse butts, these sections may be subassembled independent of the rest of the ship.

If so desired, a distinctly different method of erection and welding may be used. Erection may start with framing to keel (the keel will have been erected complete or nearly complete) and the first three shell strakes between master butts. Shores may take the place of decks or platforms to assure holding of half-breadths until all possible welding below is completed before erection of the deck. More care in shoring is necessary with this method of erection.

The framing junctures (except on the frame nearest the butt and frames to keel brackets) may be welded first, then the framing to the shell (except the last one and one-half frames at either end for fairing purposes after the butt is welded) allowing each strake to shrink both transversely and longitudinally toward the point of welding. Framing to the keel brackets and the garboard strake to flat keel butt or lap must "float" until the butt nearest midship is welded.

If we simply cut and prepared the butts of these three strakes and their framing and the decks in way of them on the midship end of the section and welded them, the shrinkage at the butt would pull the whole section toward midship a fraction of an inch, and would spring the frames in the way of the *A* strake-flat keel joint having a slight raising effect forward. This would probably have no undesirable effects if there were only one or two such master butts on either end of the hull or if the hull near the butts was not narrow or deep. If there were several master butts there would be a tendency toward keel rise as welding of butts of each series of shell, etc., progressed toward the main deck. To offset this tendency of keel rise the whole section may be forced or pulled away from midship an amount equal to the expected contraction, then the butts prepared and welded, after which the section will contract to its original position. Pulling the section forward has a tendency to close the unwelded long seam butt somewhat because it distorts the transverse frames. When welding is completed at the butt and the section has contracted to its original position, the butt will tend to open up and slightly force the section just welded away from the keel. Welding of this long seam (which has been allowed to "float" until this time) will contract it enough to relieve the tension.

If it is desired to erect the sections of the keel between master butts from keel to main deck, then make a complete master butt weld (with the possible exception of the flat and vertical keel), all welding in way of the butt must be done more or less simultaneously so as to get even contraction of the entire section toward midship and thus minimize locked-up stress.

## Erection and Welding Sequence for Cargo Vessels

As we pointed out at the beginning of this article on erection and welding sequence for cargo vessels is quite simple.

The erection and welding sequence we are going to describe for you next is not the only one that may be used. However, generally it will suffice for the average type of cargo vessel construction. We must impress upon you again that an erection and welding sequence must be tailor-made to fit the type of construction at hand.

In the preceding chapters, we have given you erection and welding sequence for bulkheads, decks, bow and stern subassemblies for vessels of longitudinal construction. We use the same basic rules in determining a sequence for those same subassemblies for cargo vessels.

The erection and welding sequence described for the subassembly of bulkheads having stiffening running in one direction only, may be used for fabricating the shell and framing subassemblies. The erection and welding sequence given for the subassembly shown in Fig. 14 may be used generally in fabricating double bottom sections. Engine foundations for Diesel and reciprocating steam engines are sometimes quite complicated and for that reason lacking the drawings for any such bases, we could only give general rules relative to them.

Beginning now with the bottom shell, we are going to describe a simple erection and welding sequence for cargo vessels.

### Erection and Welding of the Bottom Shell

Figure 15 shows the bottom shell of a cargo vessel. We show the butts staggered because that makes erection and welding a little more difficult than would be the case in a bottom designed for welding. Such a bottom would have transverse butts of all strakes (except the flat keel) in line athwartship.

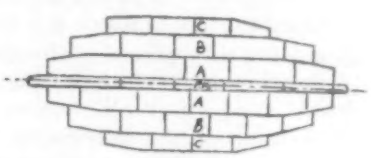


Fig. 15

The bottom shell shown in this figure still presents a fairly simple job of erection and welding sequence. We erect and weld in the same manner and order used in welding the plating of a bulkhead, by clamping the long seams so as not to restrain longitudinal contraction in each strake as the transverse butts are being welded.

Erection starts with the laying and aligning of the keel. The *A* plates are then erected and aligned, clamping them to the flat keel plates. This facilitates maintenance of alignment of the flat keel while the butts are being welded. Welding of the keel butts may then start at midship and progress fore and aft.

The *B* plates should then be erected and aligned and clamped to the *A* plates before the transverse butts of the *A* plates are welded.

After the port and starboard *A* strake transverse butts are welded, the longitudinal seams between *A* strakes and the flat keel may be welded while the *C* plates are being erected and *B* transverse butts are being welded.

If automatic welding is used, two machines should be used, working one on each side of the center line. Welding may start at one end of corresponding port and starboard long seams and progress without interruption to the opposite end.

Erection and welding may proceed in the above general manner and order fore and aft as far as shape permits and outboard as far as the bilge strake.

In a bottom having the *A*, *B* and *C* transverse butts in line athwartship, the sections of those strakes between butts may be subassembled and then erected and welded on the ways in the same general manner and

order as described above for welding the flat keel and *A* plates.

### Erection and Welding of the Double Bottom

After the bottom shell is welded, the section of double bottom near the middle of the ship or in the boiler and engine space may be erected. Either end of this section should be shored or cabled to the shell so as to hold alignment port and starboard. (See Figs. 16 and 17.)

Fitting may start by clamping the *CVK*, any longitudinal bulkheads, and the three floors nearest the center of the section, to the shell. Fitting will continue fore and aft in this manner, keeping two or three floors ahead of the welders.

Welding will start on the floor near the center of the section, using one or more welders on either side of the center line. After welding of this floor is completed, the *CVK* and longitudinal bulkheads may be welded to the shell fore and aft as far as the next unwelded floors. The next unwelded floors may then be welded. This manner and order of erection and welding permit the shell to contract toward the point of welding. If we tacked all floors and longitudinals to the shell before welding, the contraction of the shell would buckle the tank top, *CVK*, etc.

Before fitting has reached either end of the first section, the next sections fore and aft may be erected and shored and clamped and the tank top, *CVK* and other butts prepared and welded. These butts must all be welded simultaneously so as to get even shrinkage of each assembly toward the one to which it is being welded.

Erection and welding will proceed in the above manner and order until erection and welding of the double bottom are completed.

Erection and welding of the machinery foundations may start just as soon as welding of the double bottom in the way of them is completed.

### Erection and Welding of Bulkheads, Side Shell, Framing and Decks

Erection of the bulkheads will start next. They should be tacked and welded to the tank top as soon as they are positioned and shored. Nothing should restrain contraction of the bulkhead to the tank top.

Next comes the erection of the side shell and framing and decks. Erection of these parts of the ship, whether individually or in subassemblies, begins at midship and progresses fore and aft and upward.

We will describe the welding of the deck sections to bulkheads and shell and to one another and then drop back and give you an over-all picture of the erection and welding of the shell sections, bulkheads and decks.

Figure 18 shows a main deck divided into subassemblies. Erection of these sections should start near midship or in the way of machinery spaces and erection and welding should proceed fore and aft in sequence with erection and welding of the shell and framing.

When each section of deck is erected and positioned, the transverse bulkheads may be tacked to them. Any longitudinal members, however, must be clamped to the deck so as not to restrain longitudinal shrinkage of the deck as the bulkheads and other deck sections are welded to it. Welding of all transverse bulkheads to each section must be completed before the next section is welded to it. Butts in any longitudinal members under or between decks must be tacked and welded simultaneously with the deck plating butts between sections. *Any welding which shrinks the deck or the members under it longitudinally must precede tacking and welding of the deck to the shell, and all longitudinal shrinkage must have taken place in both deck and shell before the two are welded together.* As long as the two above rules are adhered to, no particular order of welding deck and shell need be considered.

Now, as we said a few minutes ago, we are going to drop back in our erection and welding sequence and give you an over-all picture of hull erection and welding above the tank top.

Figure 19 shows the profile of a cargo vessel hull.

Erection of shell plating (whether in sections or single pieces) may start after sufficient transverse bulkheads have been welded to the tank top near midship. Of course if the shell is not erected in sections with the frames attached, the frames may have to be erected ahead of the shell. Assuming the shell is subassembled in sections, we start by erecting the section nearest midship. The frames may be tacked to the tank top and, starting near the center of the section, welding may progress fore and aft and upward from that point. Nothing must restrict the longitudinal shrinkage of the shell. This applies equally well if the butts are staggered. If the upper shell butts are staggered and erection is plate by plate, the same general method of erection and welding is used, except that more pieces must be erected ahead of welding.

In order to simplify the explanation of erection and welding sequence from this point on, we are going to ask you to use your imagination. We have purposely omitted erection and welding of the bilge plates up to this point, and if you are wondering about them at this time, please forget them for the time being and concentrate on the drawing before you.

As we said before, this picture represents the profile of a ship's hull, but we want you to see it as merely a wall, made up of subassembled sections of plating. Imagine

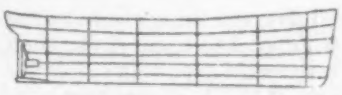

Fig. 19—Hull Profile, Assembly Sections (Shell)

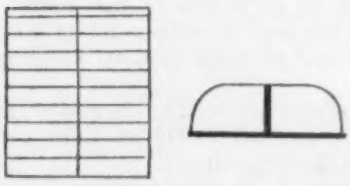

Fig. 16—Double Bottom Section, Cargo Vessel. (Left) Inverted Plan View. (Right) Inverted Elevation

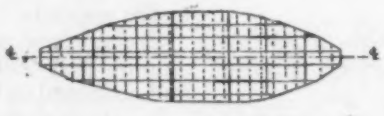

Fig. 17—Plan View—Tank Top (Double Bottom) Cargo Vessel

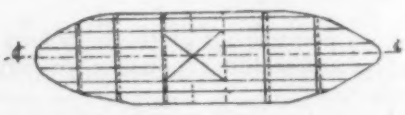

Fig. 18—Plan View—Main Deck, Cargo Vessel

that there are no decks, bulkheads or framing on the other side.

Now, we have a job of erection and welding which is just *as simple as the erection and welding of the plating of a bulkhead.*

Erection and welding will have to be carried out a little differently, however, as this job is in a vertical position.

We start erection with the first bottom section near the center. The next sections fore and aft are added and the butts between welded. Erection of these sections along the bottom may proceed toward either end of the wall. The first plate or assembly of plating near the center in the next course above may be erected one or two sections behind erection of the section below. As sections are added to it fore and aft, they must be clamped to the course below so as not to restrict longitudinal shrinkage. Welding of each course to the one below must not be carried closer than one section behind erection. In other words, the vertical sectional butt shall have been welded and the next section ahead erected and that butt tacked before welding between courses may be carried beyond the welded butt. It may be necessary to erect several sections ahead of the welders in order to permit erection of decks.

Erection and welding may proceed in the above manner until the wall is completed.

Now, if you will use your imagination again and visualize on the other side of this wall, another similar wall, with deck, bulkheads and framing sandwiched between the two, and also visualize the erection and welding of this mass of steel in sequence with the welding of the steel wall described above, except for the bilge plates and possibly the superstructure, you have the erection and welding sequence of a cargo vessel's hull structure above the tank top. But for the two items noted above and a few minor detail problems arising because of design, the *erection and welding sequence for cargo vessels is that simple.*

### Erection and Welding of the Superstructure

Where possible, the superstructure should be subassembled with the main deck sections. If this is not possible, it may be subassembled apart from the deck or it may be erected piece by piece by clamping to the deck and the bulkhead junctures welded before tacking or welding the entire assembly to the deck. If the superstructure is subassembled with the main deck sections, the butts between sections must be welded simultaneously with the deck sectional butts.

### Erection and Welding of the Bilge Plates

The bilge plates could have been erected with the bottom section of shell above the tank top or after the completion of welding of the first sections of shell plating above the tank top. Should it be desirous to leave these plates off for accessibility, it would only be necessary that they be erected and welded after the erection of the main deck.

Erection and welding plate by plate may proceed in the following manner: The plate nearest midship may be erected first by clamping it to the floors and by clamping the long seams. Welding will start near the center floor, welding it to the plate. The long seams will then be welded either way to the next unwelded floors. Those floors are then welded, followed by the welding of the long seams both ways to the next unwelded floors, etc., until the plating butts are reached. These butts are welded in turn as they are reached, and welding of the floors and long seams will proceed on in this manner until all bilge plates are erected and welded.

### Conclusion

Much could be done to further advance welding and give it the credit it deserves.

It seems to be human nature that when a faster method of doing something is found, it is used as an excuse to cut corners. Cutting corners is quite all right if a good serviceable product is turned out, but if the product does not meet the desired specifications, or is apt to come apart in service, it is time to find the reason. That time has already arrived and is with us in certain cases of recent failures in welded steel ship construction. Some yards are, possibly unknowingly, cutting corners by eliminating steps to reduce residual stress, and when a ship constructed under those conditions goes to sea, her performance is to some extent uncertain.

While steel shipbuilding has remained practically dormant since the last war, welding has progressed in most other lines of manufacturing where metals are used. The present growth of shipbuilding has mushroomed within two or three years to many times its normal size, and the men who understood both welding and steel ship construction were none too plentiful even in normal times. The result of this is that responsible supervisory positions in the shipyards which should be filled by men who are familiar with welding as well as steel ship construction, are filled by men who either have had no previous steel shipbuilding experience or are men who were considered good shipbuilders in the days of riveted construction, and consequently know little or nothing with respect to the art and science of welding.

At the present time we are spending a very large amount of money to educate the new men who started as trainees and are being schooled to become mechanics. Practically nothing, however, has been done to train the leadmen, foremen and other supervisors. As a result of this in the steel shipbuilding industry, we are very short of supervisory personnel who have an adequate knowledge of their job. Something should be done to educate these men in order to balance the shipbuilding training program so that we can better utilize our man power and at the same time have a greater regard for the ultimate cost of construction.

All of the many and various things that make for the advancement of welding depend in a great measure one thing upon the other, and perhaps that is why welding has come so short of progressing to the point it could have attained in the last decade.

Permit me to quote from a lecture given several years ago before the Association of American Shipbuilders and Designers of Quincy, Mass., by Warship Inspector Joseph R. Dean at Fore River, Mass. It might be well to consider the suggestions and predictions of Inspector Dean. I quote:

. . . In my time (25 years of steel warship construction) despite the introduction of air with its machine riveting, drilling, chipping, caulking and other applications, none or all have had the radical effects fairly attributable to electric welding. Radical though the introduction of electric welding has proved, it appears sensible to me to mention to you young and eager welders that welding today fails to occupy its rightful place because of the incompetency of welders in a larger way than simple welding permits.

"Reflect a moment on what I said and see if it isn't only too true. Harsh though it may seem on first hearing, yet on study, it contains much of hope. Why? Let me explain. You welders know well that welders

are known in industrial language as service workers.

"That is, they render service but under orders of another craft or crafts.

"What craft or crafts? Well, there are the loftsmen, shipfitters, tinsmiths, machinists, electricians and boilermakers. How often do you see one of the foregoing mechanics telling a welder what to do? Is it not very often? With such facts before me, I predict that the day isn't far distant when the welder will have a far greater say in what shall be done rather than to stand by and be told what is to be done. And why? Simply because the authority on welding will be the welder and not another craft not primarily interested in welding. . . .

"When will the welder become the main worker instead of the secondary worker? The answer is, when he learns more about the science of welding, in addition to what he already knows about the art. Just what is the difference between the art and the science of welding? It is the difference between the skill required to weld and the knowledge needed to understand why welding is being done exactly as it is. The welder of the near future will know sequence and will follow it voluntarily with craft pride, will be able to read the blueprint, tell what is called for, check the work to see if it is in agreement with the plan and even know enough to check the plan to see if it is in agrement with good welding practice and the specifications of welding.

"A large order, perhaps, yet an order that the abler men among you will fill, and fill with satisfaction to yourselves and to the betterment of steel shipbuilding.

"There is evidence that the drafting offices are failing to recognize welding at its value, regarding it as more practical than technical. This may not be best for the industry but it does give you welders a better chance to know welding requirements and to acquaint office men with them even if some reverse action would thus be in order. All this will tend toward making the welder the real voice on welding. To you younger men the field of welding, as viewed by me, this offers a fruitful harvest.

"Thus it is that I offer my experience to you welders . . . as an onward step in the movement to promote welding which, in my opinion, can't be promoted to its greater value unless the welder advances to the position of master of the welding craft. . . ."

We might ask ourselves a few pertinent questions:

Does welding "occupy its rightful place" in industry?

Has the authority on welding become the welder?

Has the welder become "the main worker instead of secondary worker?"

Has he learned more about the science of welding?

Has he learned blueprint reading?

Does he know erection and welding sequence?

Has he learned welding specifications?

Much has been accomplished along all of these lines since Warship Inspector Dean delivered his lecture several years ago. However, welding still falls short of occupying its rightful place in industry. Undoubtedly more advancement has been accomplished in the art and science of welding in the ten years past than has previously taken place in the history of welding. It is fair to assume that greater advancement will be accomplished within the next five years than ever before.

Welding is still handicapped because of the reluctance of designers to eliminate the combination of riveted and welded construction and to design for welding, and also to develop construction which can be more easily "stress free" welded.

While it is true that the welder has become the authority on welding in a good many shipyards, still there are many yards where he has very little to say in this respect. He has not become the main or principal worker from the designing welding engineer down to the man who performs the actual welding. The time is coming, however, when the designing welding engineer will take over the job after the basic designing has been done and will complete designing from a welder's or welding engineer's viewpoint. The supervision of the construction, including the erection and welding sequence and the actual supervision of the workman, will be the job of a welding engineer or someone who thoroughly understands welding as well as steel ship construction. Whether this trend of advancing welding will extend to the mechanic who uses the tools is problematical. Suffice it to say that the preparation of a welding job must satisfy the welder just as the preparation of a riveted joint must satisfy the riveter because he is most concerned as to whether his part of the job is going to be a success.

A survey of the shipyards, along the west coast, clearly indicates that those yards which approached welded steel ship construction as just another welding job are having far less trouble and are doing a far better job than those who are trying to use construction methods which were practical only with riveted construction.

It is my considered opinion that we have come a long way since the days of a ship being the pride and joy of its owner and the pride and joy of its builder, where everything that went into a ship was practically hand tailored to fit in with its plans and specifications.

The present era of shipbuilding, however, is streamlined by assembly line mass production and prefabrication of large assemblies. That old fallacy that shipbuilding was a deep, dark mystery known only to a chosen few by "Divine Right" has been exploded because of the fact that simplification of design and construction methods have been brought about by welding.


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# Machine Welded Metal Tubing*

By G. C. Gridley†

IN October 1939, it was my pleasure to present before a meeting of the AMERICAN WELDING SOCIETY a paper entitled "Welding Propeller Shaft Tubing for the Automotive Industry," which was later published in the March 1940 issue of THE WELDING JOURNAL. Since that time, increasing interest in oxyacetylene high-speed tube welding—interest intensified by the vital role it is playing in the present war effort—has made infinitely desirable a comprehensive summary of its place in war industry and a more detailed description of actual tube mill operations. To achieve this end it will be most expedient to confine this paper to an account of the operations of one mill. A more intensive study will be made possible thereby and a better opportunity afforded for careful analysis, illustration and positive demonstration.

In certain applications, welded tubing can be used to greater advantage than either solid rod or seamless tubing. Where a premium is placed on lightness and strength, tubing is superior because it is stronger for its weight. Core metal, not present in tubing, contributes the least strength per pound. For this reason tubing has supplanted solid cylindrical bars and shafts in such lightweight, high-strength structural members as automotive torque tubes—power transmitters in today's jeeps, trucks, tanks and in tomorrow's luxury cars.

Whether to use seamless or welded tubing—that was the question posed by the exit of the solid bar. Despite the distrust with which welded tubing was at first regarded, engineers had to admit that it had certain obvious advantages. It could easily be manufactured without any measurable variation in wall thickness. This feature is of prime importance in a tube which must rotate at high speed and/or support heavy loads. Variations in wall thickness are likely to cause whipping at high speeds and buckling under heavy loads.

When it was proved, further, that welded tubing is ordinarily even stronger at the weld than in the parent metal, its acceptance quickly became widespread.

The Mechanics Universal Joint Division of Borg-Warner Corp., now devoting all its energies and resources to vital ordnance production, operates a highly developed mill which turns out finished tubing in one uninterrupted, high-speed process. After previous experimentation with various methods, our engineers have settled on oxyacetylene welding. Today welds of the highest quality and strength are assured by a combination of factors in the gas-welding process applied in our mill. Most important among these are: a lengthwise puddle of molten metal; the surrounding of the puddle by an atmosphere which prevents oxidation; the maintenance of the puddle until all gases and impurities have escaped; and the compression of the plastic metal to produce a forging effect to refine the weld.

* Presented at the Annual Meeting, A.W.S., Chicago, Ill., Oct. 18 to 21, 1943.

† Mechanics Universal Joint Division, Borg-Warner Corp., Rockford, Ill.

## Materials

Almost any analysis of steel which is readily weldable by hand methods can be used satisfactorily for machine welding in this tube mill. Present specifications here call for S.A.E. 1020 with a carbon content of about 0.20 and manganese ranging as high as 0.60. In addition, all steels purchased by the mill must be silicon killed. As for mechanical properties of the strip, requirements for gage and width preciseness call for better than standard mill tolerances.

It is also important that camber and "snake" be limited to an absolute minimum to prevent distortion and consequent welding difficulties and prolonging of the final straightening operation. Camber may not exceed $^3/_4$ in. for any 50-ft. length. There is no appreciable difference between the width of the strip and the circumference of the finished tubing.

Oxygen is piped from 20 cylinders, linked together in a manifold in such a way that 10 cylinders stand in reserve while the others are being drained. When the first ten are empty, the others are automatically tapped so that the flow of oxygen to the welding head continues uninterrupted. The advantages of this device are considerable. By it a large-volume continuous supply of oxygen is made available at all times and delivered to the torches at uniform pressure. Cylinder handling is reduced to a minimum, time and labor are saved and cylinder regulators spared a lot of wear and tear. And, above all, the welding head, critical center of tube mill operations, is assured the steady, unimpeded flow of oxygen, without which it cannot function with optimum efficiency. In like manner the installation of acetylene generators obviates the necessity for successive tapping of cylinders and, most important, insures a uniform flow of acetylene to the welding head.

## Early Progress of the Strip

Coils ranging from 1500 to 4000 lb. are moved from the storeroom and lifted by a chain hoist into position on a rack at the starting end of the machine. The rack, Fig. 1, accommodates two coils at a time, mounted one behind the other on roller bearings. The strip from the coil in front unwinds smoothly and passes through a set of straightening rolls under spring tension to remove the effects of coiling. Then, passing across a table and through a shear, Fig. 2, its end is squared, as is the front end of the strip immediately following it, in order to facilitate butt welding of the two. This welding is done by a special cross-seam welder, Fig. 3, while the juxtaposed ends are held in place with pneumatic clamps. In order that strip travel may proceed uninterruptedly while the weld is being made, a compensator system of pulleys, Fig. 4, is provided which carries the strip upward 10 ft. above the floor and forms a 240-ft.

slack loop to maintain strip feed into the forming rolls during the interval when strip feed from the coils must be temporarily interrupted. The importance of this compensator apparatus cannot be overstressed, for it eliminates shutdowns for laborious rethreading of new strip through the machine and/or the dangerous practice of cutting off welding flames and then, later, beginning again on a half-finished weld. The amount of spoilage thus prevented and the time saved make the device more than worth while.

The breakdown and forming rolls—10 pairs in all—through which the strip next passes, gradually roll up the edges and convert the flat strip into cylindrical shape. The gradualness of this shaping prevents stretching of the edges, and the carefully planned shape and placement of the rolls protect the half-formed strip against the introduction of flat spots, imperfect roundness or a continuous bow or sweep to the formed tube. In "free-forming," the method employed, the progressive transition from flat to round is aided by depressing the center portion of the strip while the edges are being curved upward.

A pair of vertical breakdown rolls first gives the strip a shallow U-shape. Following this, the strip flows through a bank of four pair of conductor rolls, Fig. 5, set in transverse position. These start rolling the edges upward in preparation for a second pair of breakdown rolls which deepens the U. Four more pairs of conductor rolls bring the strip to a near circle and a final set of forming rolls gives it almost its final shape.

Figure 6 shows the contours of the various forming rolls. The rolls stacked in these stands are for forming different diameters of tubing. The progressive changes in the cross-sectional shape of the strip are shown in Fig. 7. While the tube is being passed to the welding head through a set of guide rolls, the seam is parted and held in line for welding by a fin which runs along the center of the top roll.

Fig. 1

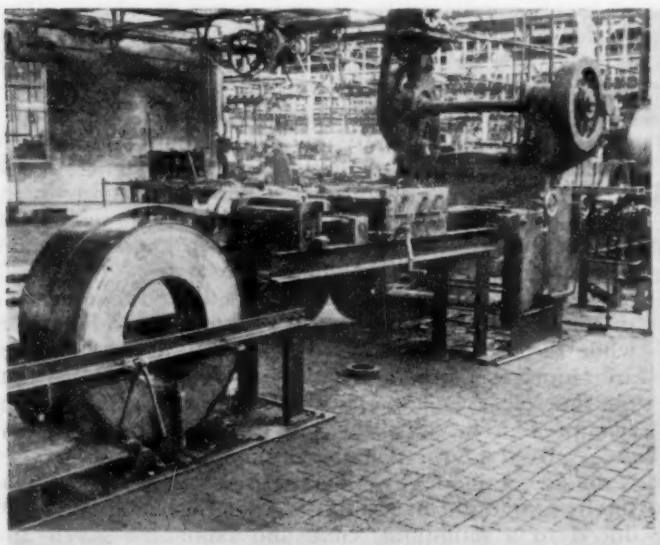
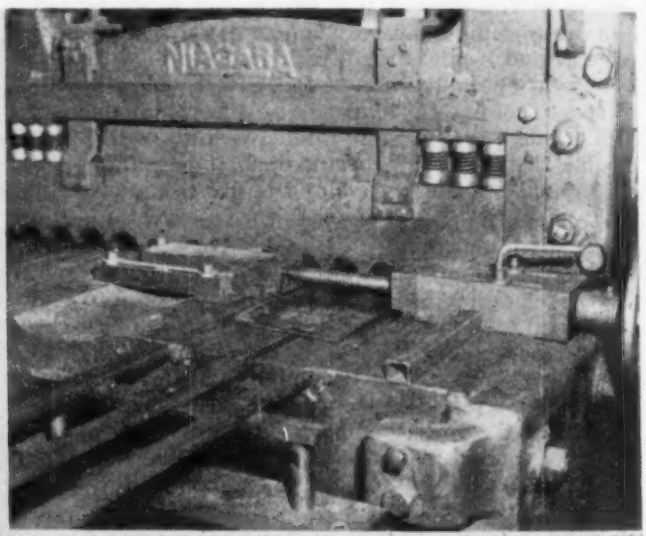


Fig. 2



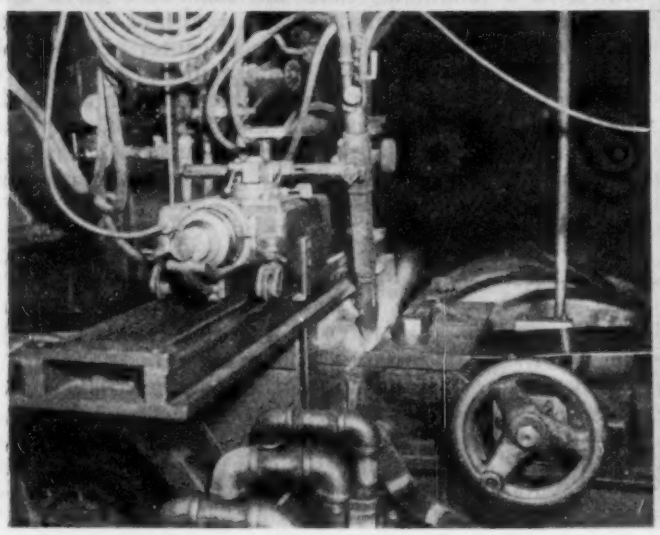



Fig. 3

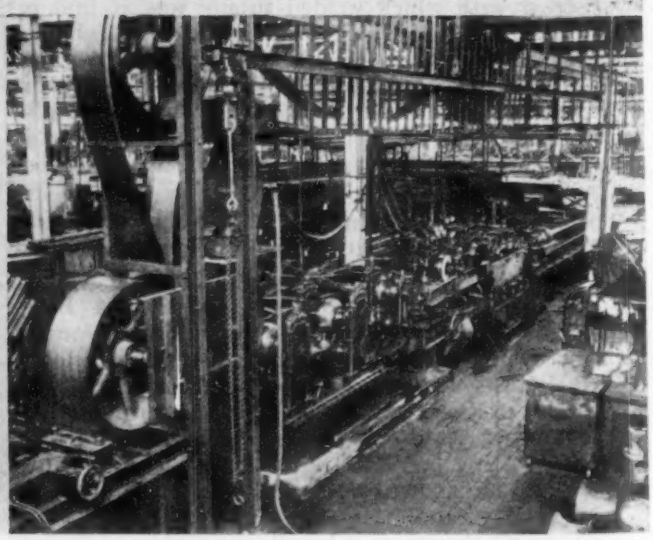


Fig. 4

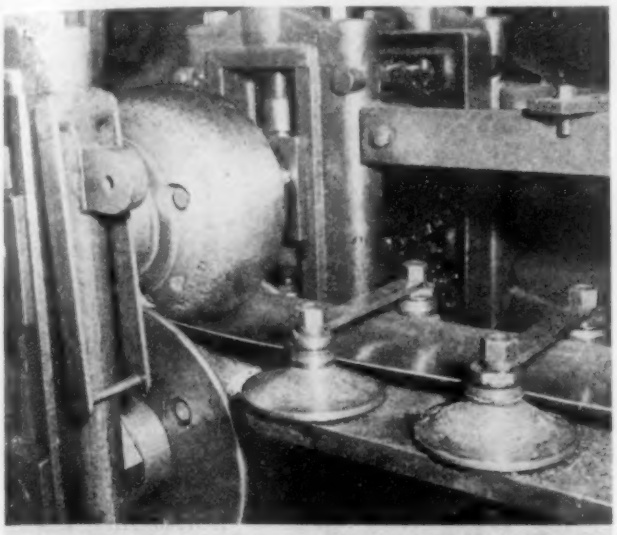
Fig. 1—Forward Coil on Rack Unwinds Easily, Passing Strip on to Straightening Rolls, Which Eliminate the "Set" Due to Coiling

Fig. 2—This Shear Trims Ends of Successive Strips So That They May Be Butt Welded Together to Form Continuous Strip

Fig. 3—Special Airco Cross-Seam Welder Butt Welds Strip Ends Held in Place with Pneumatic Clamps

Fig. 4—Strip Passes Over Pulleys to Form 240-Ft. Slack Loop to Maintain Strip Feed Into Mill While Normal Feed Interrupted for Welding

Fig. 5—After First Breakdown Rolls, Four Pair (Two Shown) of Conductor Rolls Start Rolling Edges of Strip Upward in Preparation for Second Pair of Breakdown Rolls Which Deepens U



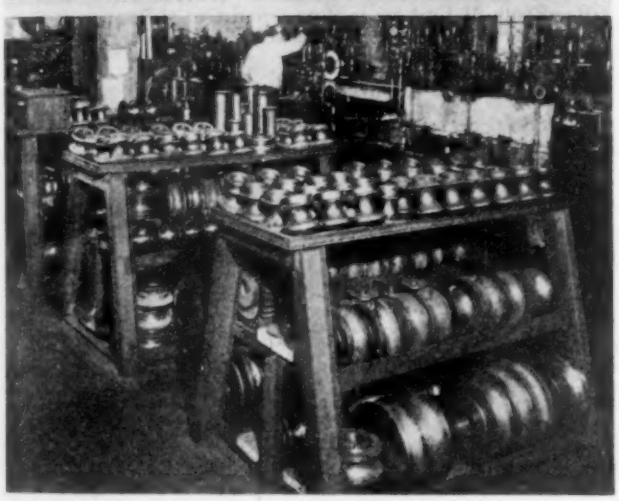


Fig. 6—Stacked Rolls for Forming Different Diameters of Tubing

The tube passes under the welding head supported by six pairs of horizontally positioned water-cooled rolls, Fig. 8, progressively elevated and depressed so that the tube passes beneath the flames in a controlled bow to equalize the effects of weld expansion at the top of the tube and, consequently to facilitate the final straightening operation. The water-cooling system in the rolls is so constructed that no steam is formed even though the lower exteriors of the rolls and the under part of the tubing are flushed constantly. The last two pairs of rolls, supporting the tube during the final stage of welding, reduce it slightly, compressing the weld to make it stronger and more ductile.

## The Welding Operation

On the strength and structure of the weld more than on anything else depends the quality of the finished tubing. For this reason the welding unit (Fig. 9) is an extremely important item. A two-torch, continuous, graduated-heat unit with an 81-orifice tip is used here. It is designed to provide for the most efficacious utilization of the flame characteristics of divers gas mixtures for preheating and welding, thus permitting higher welding speeds and reducing gas consumption.

This is accomplished by graduated heating. As the tubing passes under the welding head, two rows of flames preheat the edge metal on either side of the seam so that the heat from the following single row of flames will instantly fuse the edges without being lost to adjacent areas. The first flames encountered by the tubing burn a high proportion of oxygen thus producing a higher flame temperature and a resulting higher rate of preheating without danger of oxidation of the metal which is not yet molten. From that point on the proportion of oxygen is decreased in each successive flame until, at the end of the double-orifice section, the flames are more nearly neutral and non-oxidizing. This transition is continued throughout the length of the single orifice section so that the dividing line between the preheating and welding sections is purely arbitrary.

Throughout the welding stage, an experienced operator exercises threefold control over the procedure. Owing to the intensely localized melting in welds of this type, the operator is able to observe the fusing of the metal, the bridging of the seam by the molten puddle, the throwing off of impurities and the change from a liquid to a plastic state. Where any alteration in the procedure is called for, he can adjust the heat, position and gas pressure of the torches. These adjustments give him control over the quantity of edge metal melted, the length and breadth of the molten puddle and the cross-sectional area of the weld produced. In his hands, therefore, for the most part, lie the character and quality of the finished weld. It is his responsibility to insure thorough fusion throughout the thickness of the metal and to allow sufficient time for gases and impurities to escape.

The flexibility of flame adjustment entailed makes possible the burning of both oxygen and acetylene at optimum efficiency and a consequent saving in both gases, whatever the welding speed. In addition welding may be stepped up to any speed consistent with practical limitations imposed by the size of the machine, although depending, of course, to some extent on the grade and weight of steel used and the service requirements of the

Fig. 7—Transition from Flat to Round in Cross Section of Strip

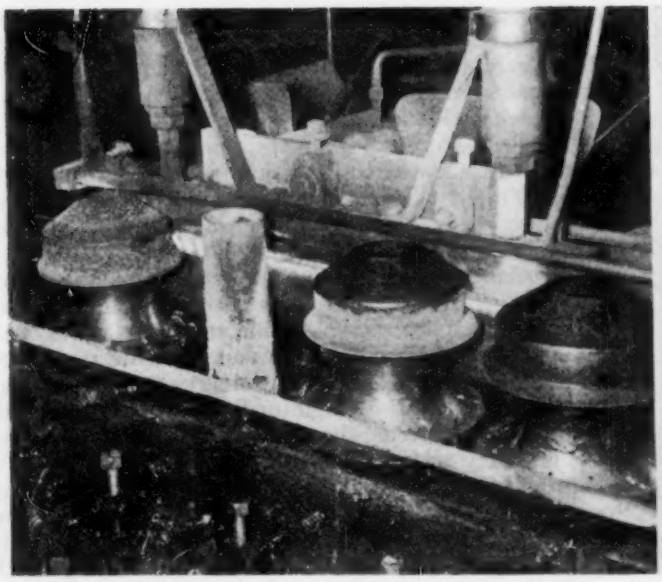


Fig. 8—As the Strip Passes Beneath Welding Flames It Is Supported by Internally Water-Cooled Rolls Progressively Elevated and Depressed to Equalize Effects of Weld Expansion

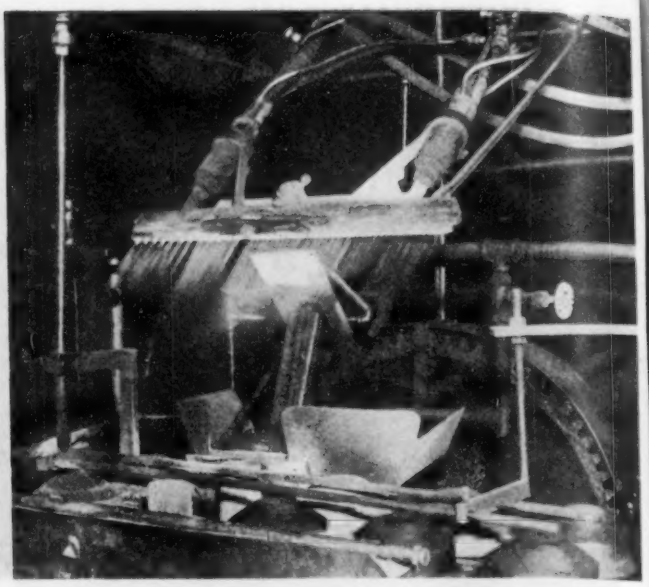


Fig. 9—The Two-Torch Continuous Graduated-Heat Welding Head with 81 Orifices Is Here Lifted Out of Position to Show Single and Double Rows of Flames

finished tubing. At this plant torque tubing passes through the mill at the following speeds: 12 gage, 12 to 13 ft. per minute; 13 gage, 15 to 16 ft. per minute; 14 gage, 18 to 19 ft. per minute; and 16 gage, 27 to 28 ft. per minute.

Gas consumption appears to vary inversely to welding speed. Responsible in part for this disparity is the liberation of hydrogen which accompanies the oxyacetylene combustion. This hydrogen, unable to burn in the high-temperature reaction of the oxyacetylene flame, escapes, some of it passing through the seam and into the tube where it burns freely, aiding in the preheating of the edges. As it is so much lighter than air, it remains trapped in the top of fast-moving tubing, doing a large share of the preheating and, incidentally, preventing oxidation of the weld by blanketing it internally and externally as it melts, solidifies and cools.

Supporting rolls carry the welded tubing through water quenches, Fig. 10, maintaining their pressure on it until it has solidified completely. The first quench effects indirect cooling of the weld by directing water jets down upon the areas adjacent to the seam on each side of it. Thus a limited rehardening is achieved without danger of excessive hardening. At the same time the rolls holding the tube permit it to assume an out-of-round or egg shape as a relief for expansion.

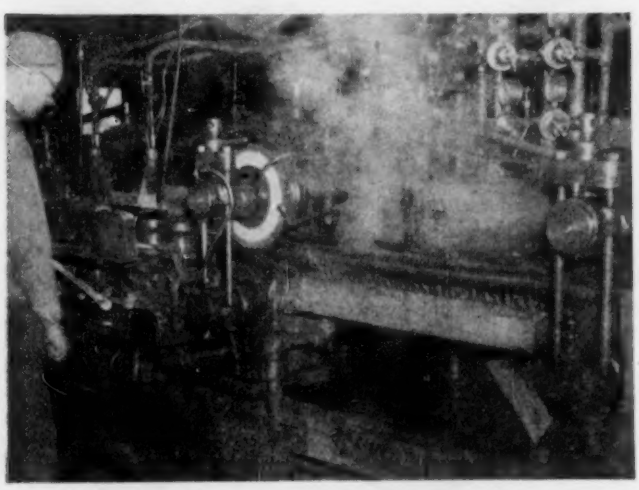


Fig. 10—Tubing, Emerging from Final Welding Rolls, Passes Under Water Quench. Jets Directed Against Areas Adjacent to Seam for Indirect Cooling

Fig. 11—Sections of Tubing Tested by Hammering with Sledge Over Tapered Mandrel. No Split in Seam of Severely Strained Sections

A final set of welding rolls compresses the tube, returning it to its circular shape and, at the same time, accurately sizing the O.D. and reducing it from 0.015 to 0.025 in. This reduction refines the weld and adds strength to the tube by virtue of the cold reduction. Another cooling quench is followed by a series of vertically mounted and staggered straightening rolls which eliminate any tendency to bow or sweep and pass the tubing on straight to within commercial tolerances.

A rotary cutoff clips off measured lengths of tubing. The tubing, passing into the cutting head, strikes a trip set at the desired length. A chuck actuated by the trip clutches and holds the tubing for 5 ft. of its progress while an attached blade makes the cut. After the cut, the traveling head strikes another trip which releases the chuck and allows the head to return to starting position. As the severed lengths of tubing emerge, hydrogen issuing from them is ignited by the flame of a stationary torch to prevent contamination of the atmosphere.

From here they roll by gravity to a deburring machine which removes the burr left by the action of the cutoff. It is only necessary to deburr one end mechanically to insure easy insertion of a swaging mandrel.

Fig. 12—Swaging Machine of Hammer-Roll Type. Hammer Rolls Press Against Outside While Mandrel Bears on Inside, Accurately Sizing Tubing and Peening Down Inside Bead

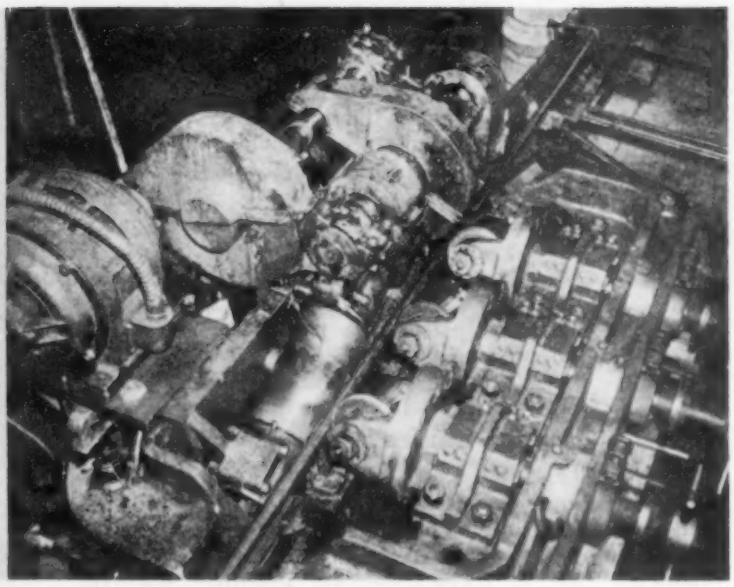


Fig. 13—Cross-Axis Rolls Pull Tubes Through Electric-Powered Multiple Straightener. Tubing Emerges Straightened to Well Within Commercial Tolerances

The multiple lengths then travel on a conveyor rack to a swaging machine. Occasionally at this point a length is selected for a manual test of the weld. The test is made on a 10-in. section of tubing which is placed over a tapered mandrel and hammered with a sledge. Figure 11, showing typical results of such a test, bears adequate testimony to the high quality of the weld. In the piece of tubing at the right, hammered until it split, the split occurred apart from the seam. The piece at the left accordioned under pressure without splitting down the seam. Tests like these are fairly conclusive evidence of the strength of the weld.

The swaging machine, Fig. 12, is of the hammer roll type. The tube is passed over a mandrel on the end of a rod slightly longer than the individual lengths of tubing. As the mandrel is located in the exact center of the swaging head, the external hammer rolls and the mandrel bear upon it simultaneously. This uniform two-way pressure insures the accurate sizing of the I.D. of the tube and peens down the bead on the inside of the tube left from the welding operation.

Emerging from the swaging machine, the tubing is forced along a V-shaped support and into an electric-powered multiple straightener, Fig. 13, through which it is pulled by a series of diagonally slanted cross-axis rolls. It emerges on a conveyor rack straightened to within a few thousandths of an inch per foot.

The straightened sections pass to a hydrostatic test bench, Fig. 14, where they are subjected to pressures ranging from 1300 to 4600 lb., the exact figure depend-

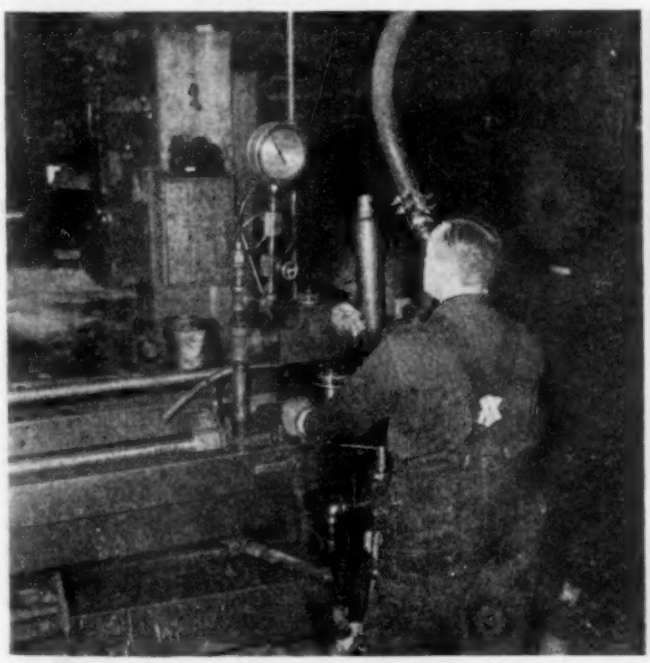


Fig. 14—On Hydrostatic Test Bench, Lengths of Tubing Are Subjected to Pressures of 1300 to 4600 Lb., Depending Upon Size and Future Service

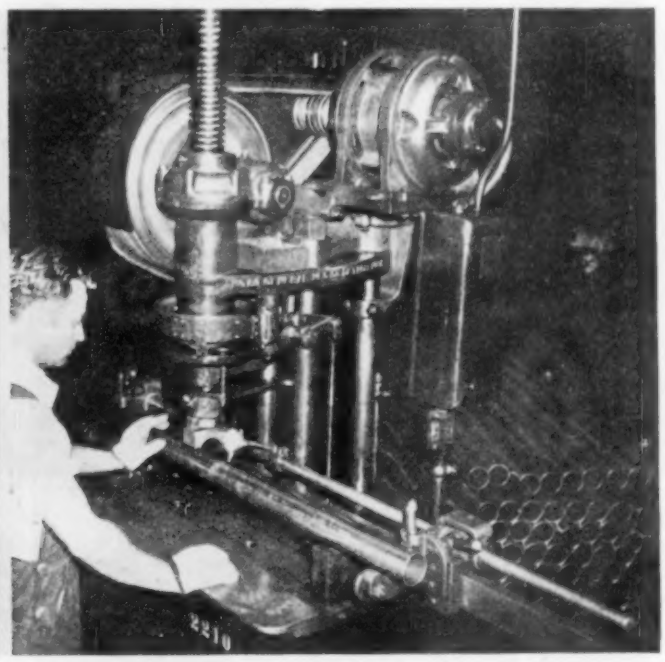


Fig. 15—Spring-Loaded Straightener Press Straightens Tubing to 0.010 In. per Length. Dial Indicator Accurately Measures O.D.

ing upon tube diameter and wall thickness. Tubes have been tested to destruction in this mill, the breaks occurring under hydrostatic pressures of 6500 to 6800 psi. In none of these tests did the failures occur at the welds.

The tested sections proceed on another conveyor rack to a final precision straightening machine. They are then cut into the required lengths and their ends, depending on the service for which the lengths are being groomed, may be chamfered and/or swaged to smaller diameter.

To cut the tube sections into required lengths an electric single-blade cutoff is used. While the tubes are being cut, the operator deburrs the new ends with a swivel-hung chamfering tool.

## Turning Out the Finished Part

A straightener press, Fig. 15, is next. Spring-loaded with a dial indicator which measures accurately the O.D., it straightens the tubing to within 0.010 in. per length. Following that, a special swaging machine, Fig. 16, narrows the ends of the lengths by uniform compression so that they may be fitted into couplings and universal joints. Scrap ends are cut off with a high-speed saw. During this operation they are supported on a platform topped with a series of notched wedges.

Fig. 16—Special Swaging Machine Narrows Ends of Lengths by Uniform Compression, Preparing Them for Fitting Onto Couplings, Etc.

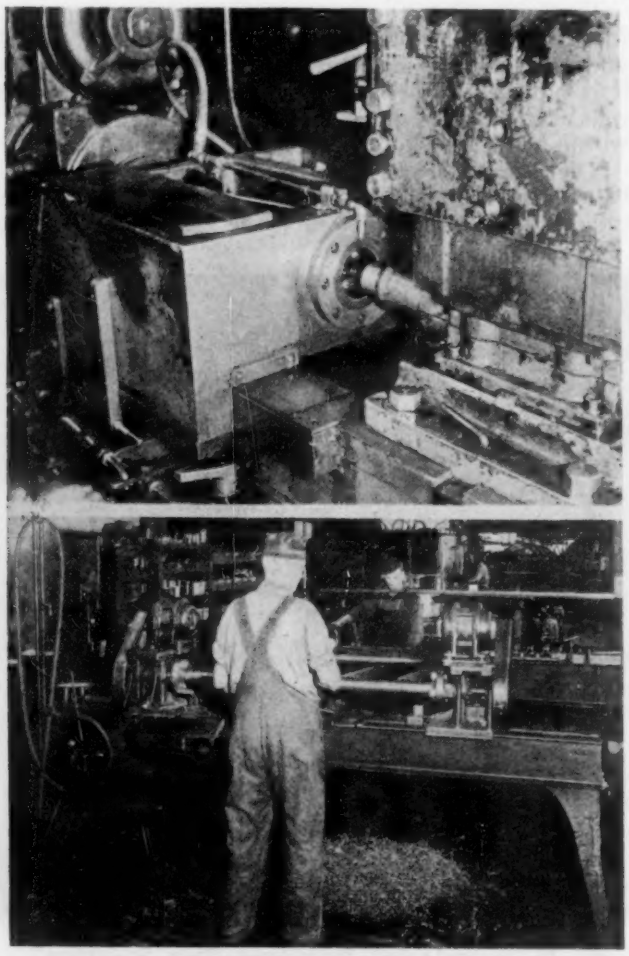


Fig. 17—Lengths Chamfered for Welding Into an Assembly. Careful Chamfering Leaves Sufficient Base Metal for Welding

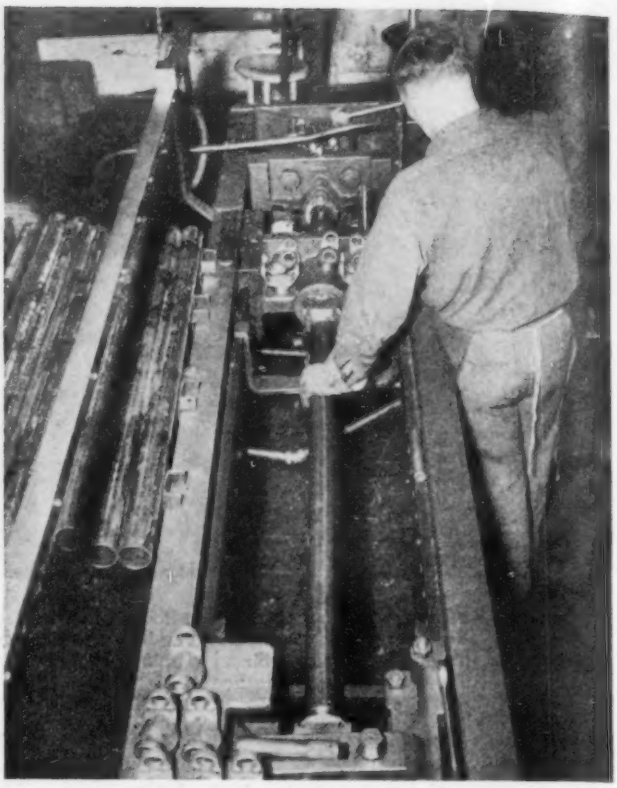


Fig. 18—Stub Ends, Yokes, Sleeves Are Pressed Into Tubing Under Pressure of 500 Lb. Length Gages Restrict Length Change to $^1/_{64}$ In. During Operation

A chamfering machine, Fig. 17, chamfers both ends of many of the lengths prior to their being welded to some assembly. The chamfer is kept at a minimum to insure the leaving of maximum base material for welding. The angle of the chamfer is usually about 45°. The head holds three tools, one for chamfer, one for squaring (both on outside) and an inside tool for slight deburring up to $^1/_{64}$ in.

A hydraulic pressing-in machine, Fig. 18, exerting 500 lb. pressure forces stub ends, yokes and sleeves into the tubing. Length gages prevent the length from changing more than $^1/_{64}$ in. during this operation. The pieces forced into the tubing are welded to it (Fig. 19) in a welding booth. Both ends are welded simultaneously using mild steel $^3/_{16}$-in. electrodes furnished in 200-lb. coils, achieving a speed of 1 ft. per minute on $2^1/_2$-in. tube, gage 13 to 15. The speed increases as the diameter and gage of the tube decrease. On 2-in. diameter a 110 amp. current is used and up to a 180 amp. current on 3-in. diameter by 11 gage. On all sizes 440 v. is the rule. The tube and attached ends are gounded through chucks.

Following this, the finished part faces its most rigorous test (Fig. 20) in a pneumatic torque testing machine. Unless the tube returns to its original alignment after the test, it is rejected. For $2^1/_2$-in. diameter 13-gage tube, the test is 2400 to 3100 ft.-lb. The testing mechanism consists, in the main, of a flat steel torque bar weighted with a 615-lb. block of metal. This bar is so placed that when it is forced backward and forward, up and down, it transmits torque to the end of the tubing inserted in the machine.

The tube is then placed on a straightener and tested for straightness by hand revolution and gage indicators. To facilitate hand-turning, roller-bearing heads are placed on each end, and the ends themselves are half-blocked so that the top and bottom may be checked more easily. Transferred to a speed lathe (Fig. 21) the tube

revolves at speeds as high as 5000 r.p.m. for passenger car tubes and 3800 r.p.m. for truck tubes. Any vibration indicating that the tube is out of balance is revealed by hand checking.

To counteract any such flaw the tube is placed in a precision balancing machine developed by General Motors (Fig. 22), connected with a delicate oscillograph, Fig. 23. The end dials register the speed of the shaft in revolutions per minute and the oscillograph indicates the exact longitudinal position in degrees and the extent of out-of-balance in inch-ounces. To eliminate disparity in out-of-balance between the two shaft ends, they may be balanced separately.

To counteract out-of-balance a lead spray, Fig. 24, is directed against the underweight portions of the tube. Between deposits the balance is rechecked by the operator. The more experienced the operator, the fewer will be the rechecking stops necessary. The spray is produced by insertion of a lead rod into the melting tip of a sprayer as illustrated.

Tubing of this sort is especially suitable for use in automotive torque shafts. It is perfectly straight and, because it has been formed from precisely measured flat strip, it is of absolutely uniform wall thickness. These two characteristics make it ideal for parts which will be required to rotate at high speeds under a heavy load. Its superiority in this respect has not gone unnoticed. Already many thousands of miles of this tubing have gone into the weapons of Victory. More and more, peeps, jeeps, tanks, trucks, half-tracks, staff and reconnaissance cars are being furnished with drive shafting of this type.

Just where welded tubing is going today may be seen from a quick glance at our contracts. We are at this time furnishing tubing for Army aircraft, tanks, tank destroyers, primemovers and half-tracks, and for Army, Navy and Marine Corps trucks and tractors. Welded tubing manufactured in our plant is now being used in the Lockheed Constellation transport plane. The list of tanks includes the M-5, M-5Al and T9-El, manufac-

Fig. 19

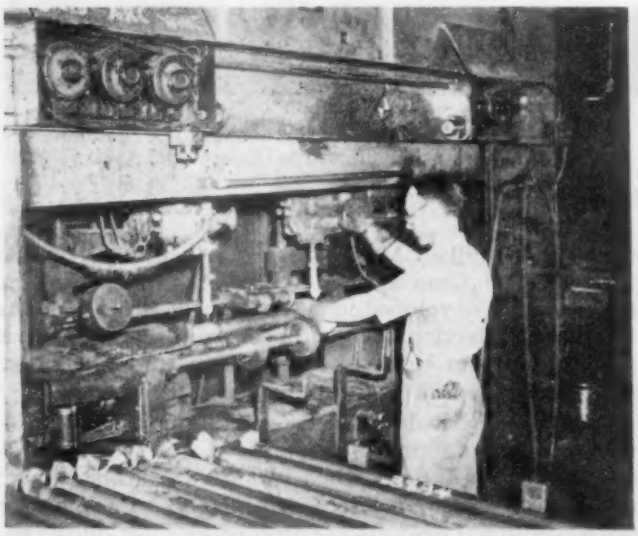


Fig. 20

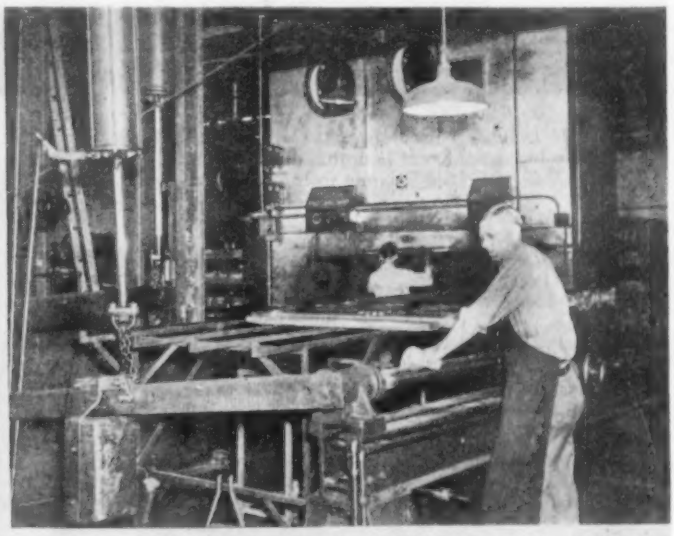


Fig. 21

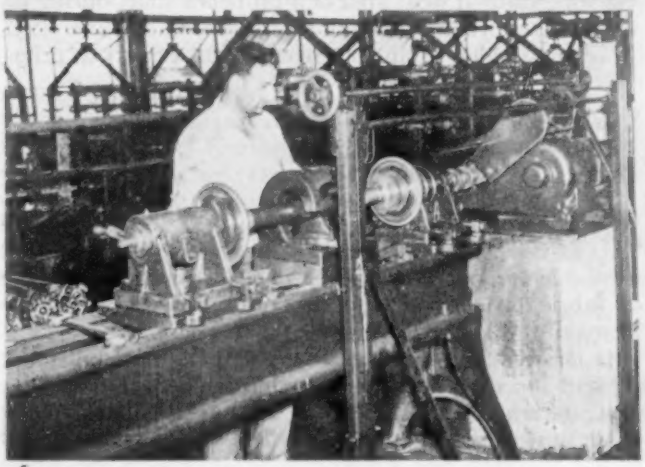


Fig. 22

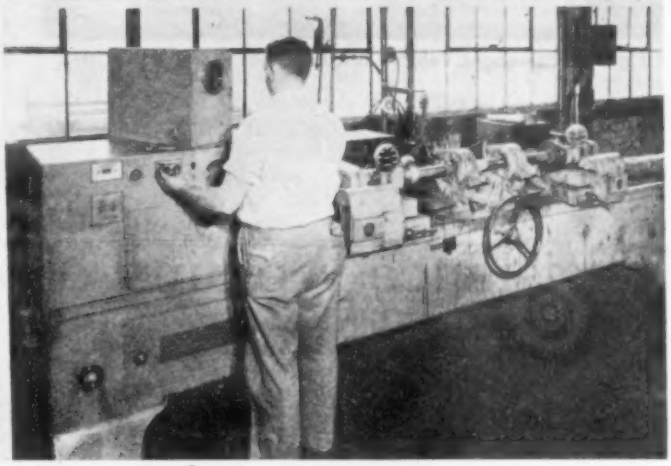


Fig. 19—Pieces Previously Pressed Into Tubing Are Here Welded to It in Welding Booth. Mild Steel $^{3}/_{16}$-In. Electrodes Used. Both Ends Welded Simultaneously

Fig. 20—Torque Testing Machine Tests Tube at 2400 to 3100 Ft.-Lb. Tubing That Fails to Return to Original Alignment After This Test Is Rejected

Fig. 21—Tube Is Rotated at 3800 or 5000 R.P.M. on This Speed Lathe. Vibration Indicates Out-of-Balance, Which Is Then Checked by Hand

Fig. 22—General Motors Precision Balancing Machine to Counteract Out-of-Balance. End Dials Register Speed of Shaft in R.P.M.

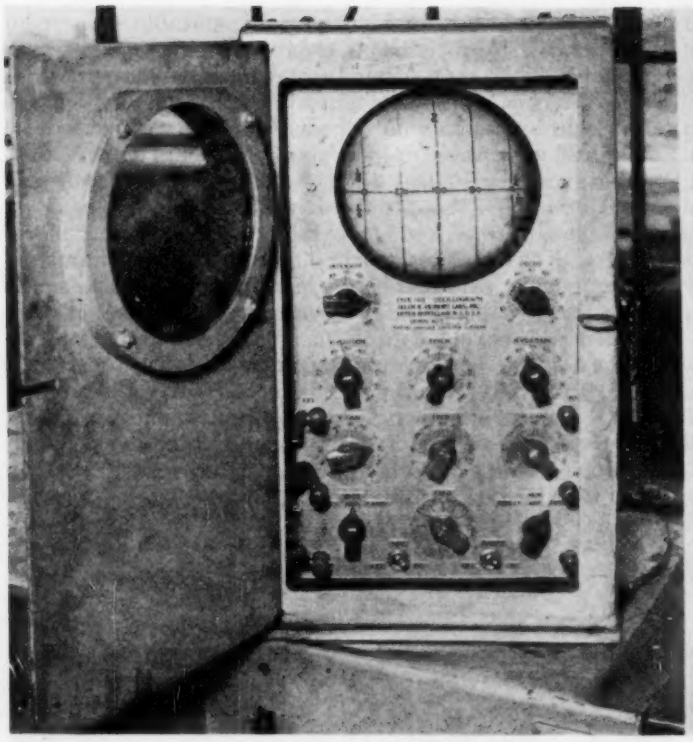


Fig. 23—Delicate Oscillograph Connected with Balancing Machine Indicates Exact Longitudinal Position in Degrees and Out-of-Balance in Inch-Ounces

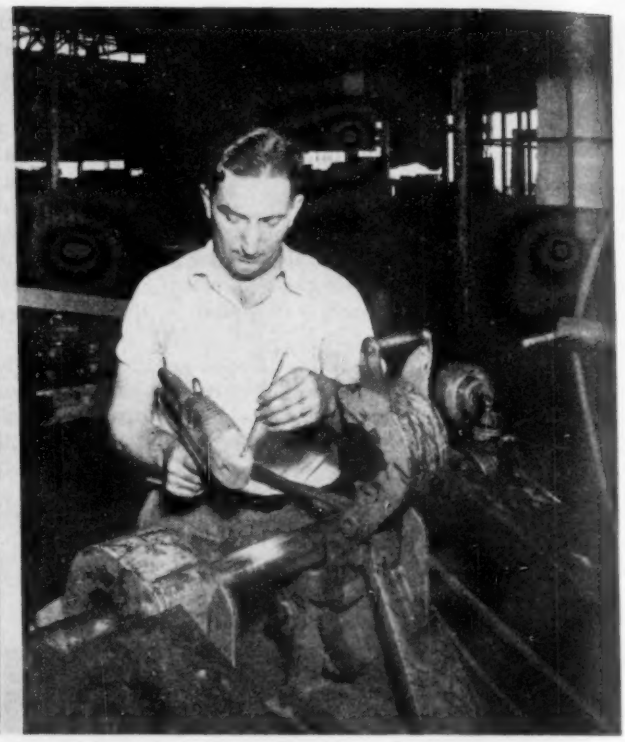


Fig. 24—Lead Spray Corrects Out-of-Balance by Adding Thin Sprinkling of Lead to Underweight Areas

Fig. 25—Passenger Vehicle Torque Tubes Produced in 1941

tured by Cadillac, Massey-Harris, American Car and Foundry and Lima Locomotive. One of the deadliest new weapons developed in this country—the T-70 Tank Destroyer affectionately dubbed the "Hell Cat"—is propelled by our tubing. A few of the finished torque tubes turned out in 1941 appear in Fig. 25.

And how serviceable, how dependable are these welded-tubing parts in actual use? Their record speaks for itself. It has been impossible to find, after diligent and unrelenting search, any recorded instance of a failure in the longitudinal weld area of a propeller shaft during the entire two years immediately preceding June 1942. Machine-welded tubing has reached its permanent prime.

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# Resistance Welding of the Future*

By Malcolm Clark†

I BELIEVE that the art of resistance welding as well as many other fabricating processes will undergo a tremendous period of development during the intense competition which will exist immediately subsequent to the present war. This competition will be particularly intensified by the struggle which will undoubtedly exist between stainless steel, aluminum and magnesium. The excess capacity of these materials which will be available for peacetime use will lead all manufacturers or fabricators to develop superior products at an unheard-of low cost.

It is important that we bear in mind that under our present social economy, the intrinsic or initial cost of the raw materials themselves will be but a small fraction of the cost of the completed article. The social economy which dictates our present high standards of wages will also dictate an extremely high standard of manpower utilization or manpower efficiency. This will require that the new products must be fabricated with the minimum number of man-hours and not the minimum cost of raw materials.

It becomes apparent, therefore, that those particular materials which lend themselves to a fabricating means involving the least number of man-hours will be those materials which will be used in our postwar products.

* Presented at October 21st Meeting, Los Angeles Section, A.W.S.
† President, The Federal Machine & Welder Co.

By the same token, those processes which lend themselves to the fabrication of these materials with the minimum expenditure of man-hours will be utilized most rapidly.

I hold a most emphatic view with regards to the resistance welding process being that one process which possesses an outstanding advantage in fabrication cost at the present time and will enjoy a more tremendous advantage as we further develop this relatively infant industry.

Some of the most obvious and the least fantastic predictions would involve the development of the present spot-welding machine to a degree of automatic utilization already dictated by the automotive, refrigeration and aircraft fields, such that the spot-welding machine will be a machine in the true sense of the word and an automatic machine at that. This automatic machine of the future would not produce 100,000 spot welds per 8-hr. shift but will produce 10 or 20 times that number of welds with one operator or perhaps no operator at all.

This is far from the realm of fantasy because the 100,000 spot welds per 8-hr. shift has been normal production in one of your Los Angeles aircraft plants for the past 6 months. Immediately prior to the war, the cross wires on refrigerator shelves were welded at the rate of more than one-half million welds per 8-hr. shift.

I also foresee a tremendous development in the electrode materials which will be used for spot welding points, projection welder dies, flash welder dies and seam welder wheels. I believe that these materials will be developed to such a degree of usefulness that they will not be regarded as an ordinary replaceable item but will require replacement only two or three times during an entire year's operation. I feel that this is an inevitable development in the metallurgical field of resistance welding.

We must remember that procedures that were laboratory curiosities only a short time ago are now regular production methods. Liquid nitrogen at a temperature of 400° F. below zero is now being used in wartime production.

I have visions of a nondestructive method for testing the quality and metallurgical perfection of weldments in a simple manner as a routine production check wherein each and every weldment will be automatically scanned, marked and indexed as it leaves the welding machine. Perhaps, you will say that this is not a vision but is more of a hallucination. Perhaps so, we will not quarrel on that score. However, my engineering training and experience lead me to believe that if a device can be perfected to detect the approach of an enemy aircraft within a 20- or 50-mile radius, or if this device can likewise detect a submarine periscope, or if this device cannot only locate but direct the firing of battleships, certainly it should not be a tremendous task to develop a device which can find a void or a crack or a fault within a narrow confined region of not more than $\frac{1}{2}$ in. in diameter and at depths of only a fraction of an inch. Call it hallucinations if you will—I call it the handwriting on the wall.

I can even visualize a complete aircraft being advertised in the Sears and Roebuck catalog.

The resistance welds of the future will be practically invisible on the surface if not entirely invisible. This thought is not very fantastic; in fact, it is not even very original. On the condenser discharge stored energy spot welder used extensively for the welding of aircraft aluminum alloys, we have been able to produce almost invisible welds at the present time.

Maybe this invisible welding is not too good judging from an experience on my way West this trip. For some unexplained reason, the key to my luggage and I became separated or boarded different trains and it became necessary for me to secure a locksmith to open my bags. In forcing one of the bags open, the catch was bent somewhat and the locksmith proceeded to hammer it back into shape. Just about the time he was ready to strike the latch with the first blow of the hammer he stopped and said, "I don't believe I'd better use the hammer on this catch, I'll use the pliers. I see the catch is spot welded." Now I don't know which would have been better—visible or invisible spot welds in this case. Definitely, the visible spot weld acted as a warning signal to the locksmith, causing him to proceed with caution. On the other hand, however, if the spot weld would have been invisible, he might have hammered the catch apart by breaking the spot weld unless the spot weld happened to be made on Federal equipment.

Much has been written and published about electronics and many realistic as well as many fantastic predictions have been made regarding the application of electronics to our postwar period of living.

Electronics have played, and I believe will continue to play, an extremely important part in the resistance welding field. Prior to the application of electronic controls and ignitron contactors to resistance welding equipment, the progress of the art was rather slow. A tremendous surge of advancement in resistance welding technique resulted from the application of electronic controls to the resistance welding machine and a considerable period of prosperous development and expansion resulted in the industry.

The invisible welds which I spoke of in mild steel were accomplished, as I previously pointed out, on a condenser discharge machine but I did not point out the fact that this particular condenser discharge machine was equipped with the latest developments of fully electronic control. In these tests, we definitely established the fact that the precision of the equipment with fully electronic control was far in excess of the precision of the metallurgy of the steel itself as every departure from normal spot-welding strength was immediately traceable to a change in the analysis of the steel. Please bear in mind that this is remarkable precision for production apparatus. I believe that further development in the resistance welding technique will result from the further application of electronic controls and electronic circuits.

I believe that we shall find considerable promise in the application of the higher frequencies in the neighborhood of radio frequencies when applied to the resistance welding process. We now have available, for the first time, electronic radio frequency generators of capacities ranging up to 1000 kw. and beyond. These high powers in the radio frequency range were not available to us heretofore and the utilization of these high powers suggests tremendous possibilities when adapted to resistance welding.

I can visualize the high-frequency resistance welding of metals with an almost imperceptible bond between the faying surfaces, wherein there is no heat-affected zone whatsoever and the depth of the welds will be of molecular proportions. I can visualize a weld being performed by merely intermingling the surface molecules on the two faying surfaces. I can even visualize a weld between two dissimilar materials wherein no alloy is evident within the weld nugget because there will be a complete absence of a weld nugget as we know it today. Perhaps we shall have to coin a new phrase to describe this type of weldment. Perhaps we shall describe the quality of a weld of this nature by indicating the extent to which the crystal structure of the two faying surfaces interlock one with the other, defining the interlocking

as one, two or three crystal layers interlocked. Perhaps we shall even speak of intermolecular locking.

Impossible? Establishing the form and contour of filterable virus was also impossible until the advent of the electron microscope.

Perhaps these welds will be performed without the application of pressure.

If I keep on talking here, I will be talking myself entirely out of the resistance welding business, as we will not even need a resistance welding machine to perform a resistance weld. Perhaps all that will be required will be an Act of Congress.

Remember that we do not *need* pressure for the weld itself even today. The pressure is only required to establish electrical contact between the electrodes and the work pieces and to inhibit the growth of cracks resulting from the cooling of a rather large mass of molten material in the weld nugget. If we can make our electrical contact without sensible pressure—or more technically correct, if we can introduce the heat into the faying surfaces without the necessity for a high-pressure electrical contact on the two parts to be welded and, if at the same time, we eliminate the weld nugget entirely, where then remains the necessity for pressure?

It is interesting to visualize the possibility of fabricating a structure of rather considerable magnitude with a tool not much larger than a portable electric drill. After all, we are doing this very thing on the very lighter gages of material so why not on the heavier gages?

After we have accomplished these things, why confine ourselves to joining the two parts together in a very restricted and confined area which we now know as a spot weld. Why not bond the entire area of the two faying surfaces together with a film of molecular proportions?

Fantastic? Yes, it is fantastic, because I do not believe that it has as yet been accomplished even on the West Coast! *Or has it?*

I can even visualize the spot welding of plastics. Something of this nature is bound to develop. One of the decided limitations to the application of plastics is the difficulty of making attachments to the plastics. I cannot believe that American ingenuity and resourcefulness will long tolerate this rather definite restriction to the application and utilization of a most promising and intriguing material.

Perhaps you may accuse me of being bold in my thinking—perhaps too bold! Perhaps too fantastic! However, my intellectual integrity does not quarrel with my own conscience in proposing to you those things which I honestly believe will come to pass. I make no secret of the fact that some of these prospects, proposals or fantasies are now being investigated in the laboratories of my own company.

In closing, I give you this thought—never let it be said that American enterprise suffers from lack of imagination or imaginative engineering. Never let it be said that American enterprise lacks the courage to plan or build boldly. Let us determine that which is right—and hold to that which is good!

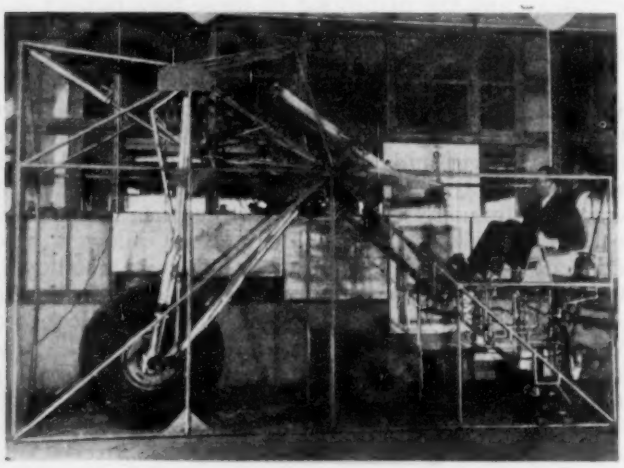
# Arc-Welded Hydraulic Airplane Landing Gear Mock-Up*

By Henry Chasen†

THIS hydraulic landing gear mock-up is a fixture or jig replacing the fuselage of an airplane and is used in training the student flyer to operate the landing gear, bomb doors, wing flaps and brakes and to make various inspections. It houses the landing wheel, hydraulic pumps, controls, tanks, pressure relief valves and lines that are used on one of the airplane bombers flown by the Army.

* The above article was one of the prize-winning entries in the Hobart Brothers Arc Welding News Contest on "Ideas for Victory."

† Instructor, New England Aircraft School, Boston, Mass.



As it was impossible for the Army to send up a complete airplane of this type for instruction, it became my job to construct this mock-up and as classes were to start almost immediately in this kind of instruction, we had just 28 days to complete the unit. After receiving the blue prints of a similar mock-up used by the Army School at Chanute Field, I found to my surprise that this unit called for Chrome-moly 4130, 20-gage aircraft tubing and practically all bolted joints, although some joints were constructed of aircraft type fittings and were acetylene welded. An estimate showed that this job would be expensive and take about three months to construct with the limited facilities we had available.

We had previously obtained 2000 ft. of old boiler pipe from a second-hand dealer and had used it to fabricate many units such as propeller dollies, engine change work stands, stepladders, barrel dollies and airplane fuselage tail stands. We prepared the shop drawings, used this second-hand boiler pipe and constructed the mock-up by arc welding. Using a poor fit-up electrode, grinding and fitting of tubular joints were eliminated and much time was saved. The main joints were reinforced with $^1/_4$ in. boiler-plate gussets.

The estimated time required for the construction of a mock-up to Army specifications was 12 weeks and our job was completed in three weeks, a saving in time of 75%. Estimated cost of mock-up to Army specifications was $465.00. Our cost $229.10, a saving of $235.90.

This hydraulic mock-up unit has been copied by other air schools in many parts of the country and has been in operation since the day it was completed, giving us splendid service. All of the work was done by the students of the New England Aircraft School (Army Division) under my supervision.

# The Control of Welding in Shipbuilding*

By Russell W. Brendle†

## Introduction

THE purpose of this paper is to stress the necessity for and the operations of a Welding Control Center, and not to lay down hard and fast rules concerning the control of welding in shipbuilding, or to specifically point out steps to be taken in building welded ships.

In many shipyards and, in fact, in other industries, various welding and allied processes are used and controlled by the departments or crafts in which such equipment is located and little or no effort is made to determine whether or not this equipment is being used to its best advantage.

A Welding Control Center must keep abreast of all new developments and methods. Its purpose and function in a shipyard may be described as follows:

1. To assist in the design or redesign of ship construction, wherever welding is used.
2. To give advice on welding problems in ship repair and conversion.
3. To supervise the training and testing of welding operators.
4. To set up specifications for and requisition, necessary welding equipment and supplies.
5. To set up written welding procedures for all structural drawings of new ship construction.
6. To develop and work out applications of various allied processes.
7. To coordinate with yard operating divisions.

To touch briefly on each of the above subjects, consider the following points.

* Presented at the Annual Meeting, A. W. S., Chicago, Ill., Oct. 18 to 21, 1943.

† Welding Engineer, Tampa Shipbuilding Co., Inc., Tampa, Fla.

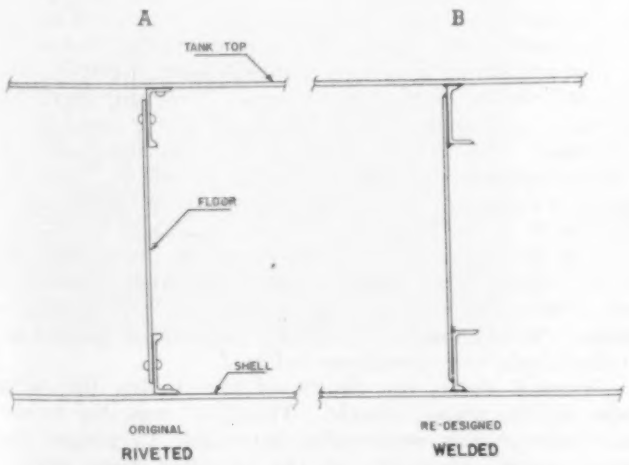



Fig. 1—Redesign of Ship's Inner Bottom for Welding

*Design and Redesign*

Much has been written and published on designing for welding and redesigning to take advantage of welded construction. Joint designs for both manual and automatic welding are now more or less standardized. Today, we know what to expect from an individual welded connection when put into service.

However, a Welding Control Center faces many problems. For example, Fig. 1 (*A*) shows a standard riveted design of the inner bottom of a C-2 vessel that had been converted to Navy use. Figure 1 (*B*) shows the redesign of the same inner bottom of a similar vessel for welding, utilizing materials which were already on hand and which, of necessity, had to be used.

This was not the only change made in this design—

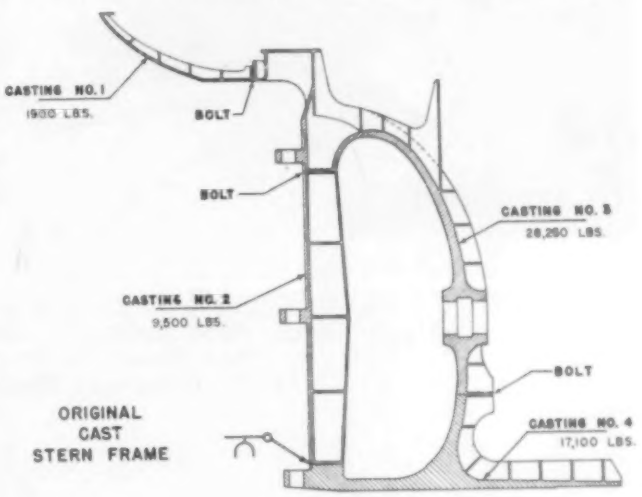



Fig. 2

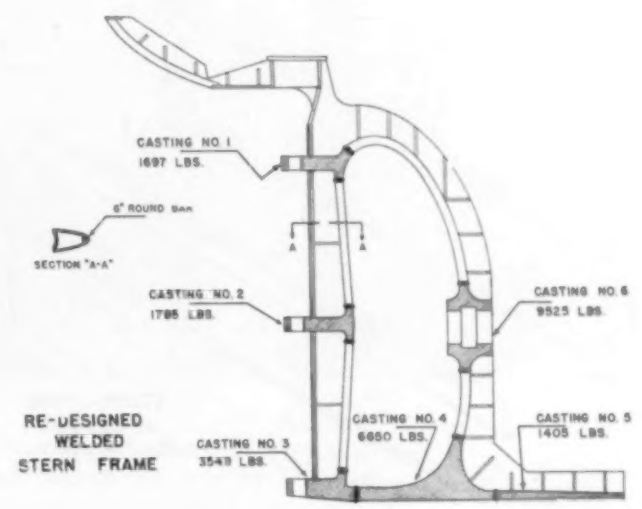
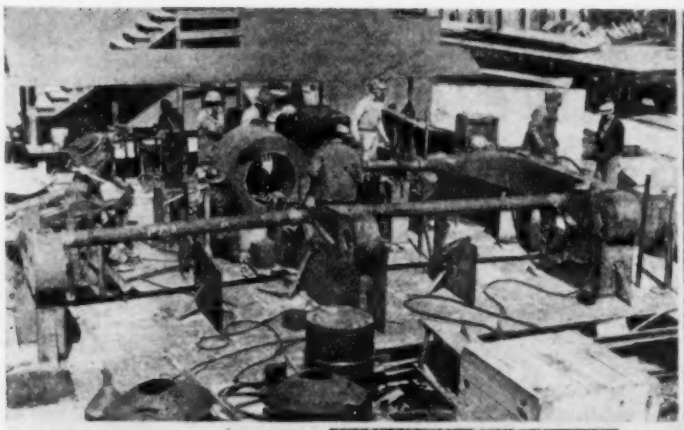
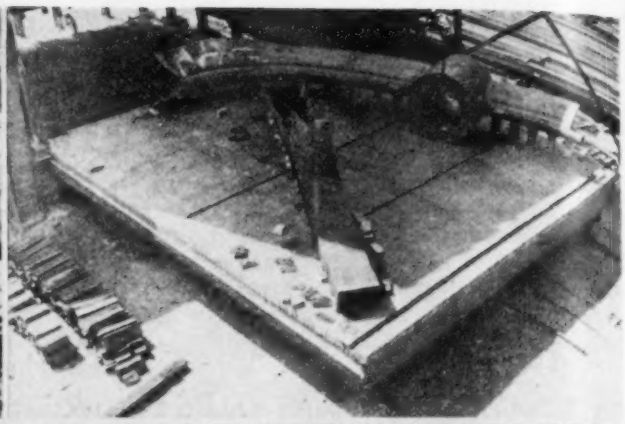


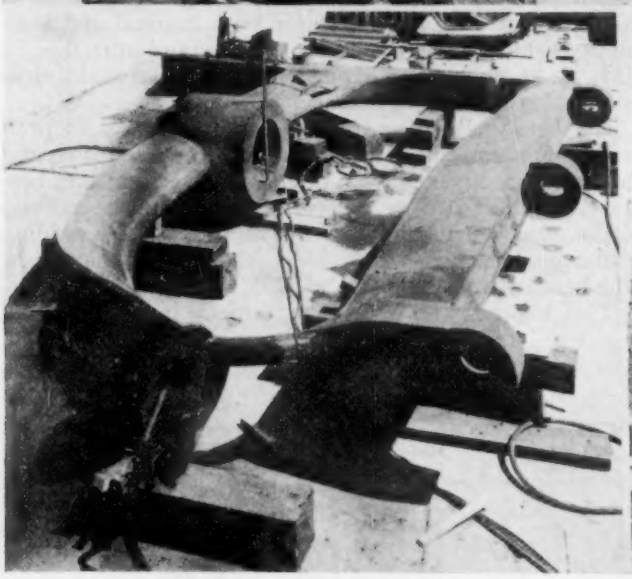

Fig. 3

Fig. 4

Fig. 5







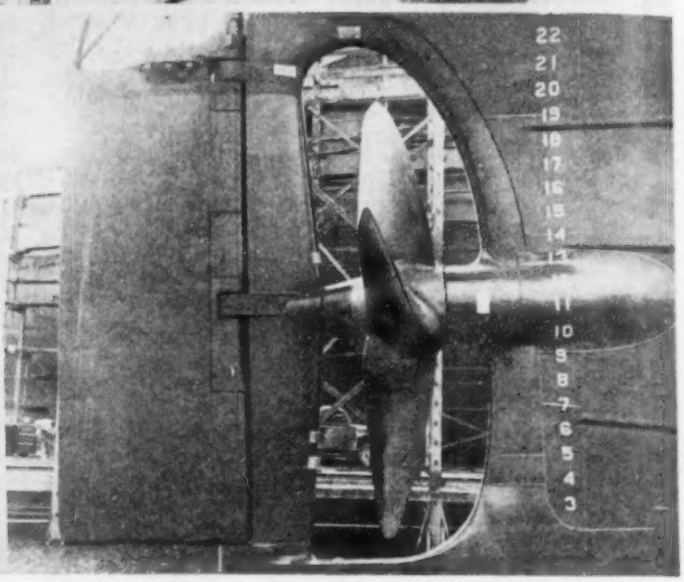



Fig. 6

Fig. 7

Fig. 4—Alignment of Castings and Forgings for Thermit Welding
Fig. 5—Stern Frame Sections on Car Bottom of Stress-Relieving Furnace
Fig. 6—Stern Frame Sections Assembled for Final Welding
Fig. 7—Completed Stern Frame Installed in Ship

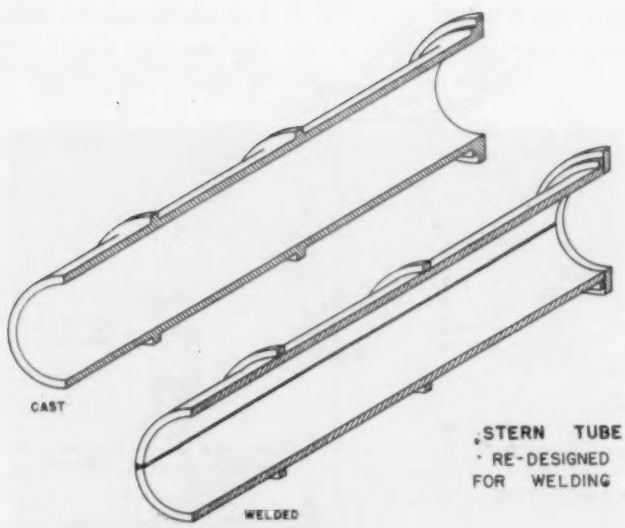



Fig. 8

connection clips of all intercostal longitudinals, boundary angles of solid floors and center vertical keels were dispensed with. In all, over 40,000 rivets were eliminated, including the accompanying drilling, punching, bolting and reaming.

In addition, a saving of 25% in lofting time was effected and since there was a shortage of riveters in this area, erection time on the ways was greatly reduced.

Figure 2 shows a cast steel stern frame, a part of the original design of the above vessel. Several foundries in the South were unable to supply these castings on scheduled time because of their size. However, it was known that smaller castings, under 10,000 lb., could be easily obtained in that area. By utilizing forged round bars with these smaller castings, as shown in Fig. 3, a stern frame was successfully designed and fabricated. This served the purpose and permitted launching schedules to be met. Figures 4, 5 and 6 show the stern frame during fabrication. The completed frame installed in the vessel is shown in Fig. 7.

Figure 8 shows the results of redesigning the stern tube for the above vessels. This, too, was due to the fact that it was practically impossible to obtain the large casting necessary in the specified time period. There is, virtually, no part of a ship in which saving of

weight, time or material cannot be effected through welding.

*Ship Repair and Conversion*

In ship repair and conversion, numerous problems involving the rebuilding of damaged hulls and the repair of sabotaged or broken machinery are encountered daily. The function of a Welding Control Center in this connection is to give timely advice on how welding may be utilized, so that these much needed hulls are correctly repaired and again sent to sea in good condition in the shortest possible time.

Oxyacetylene welding, thermit welding, arc welding, silver soldering and bronze welding, when correctly applied, can shorten the time from days to hours in the repair of many parts of a vessel. Figures 9, 10, 11 and 12 show examples of such repairs.

*Training and Testing of Welding Operators*

In supervising the training and testing of welding operators, the function of the Welding Control Center, during the present manpower shortage, is to determine exactly the type of training which will best suit needs of the individual yard with its own welding conditions and problems. Setting up a proper curriculum of instruction, whether for use in the yard's own school, or in private or vocational schools, is a relatively simple matter, and I know of no case where private or vocational schools have refused to give the type of training necessary. Many recent papers have been published on

Fig. 9

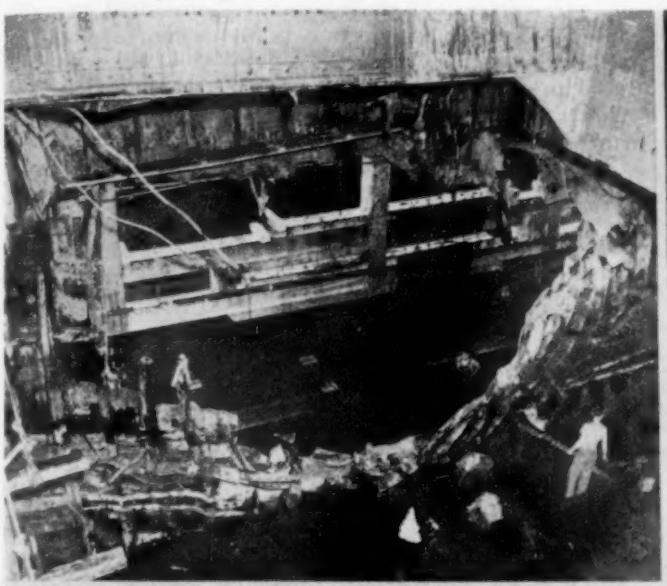
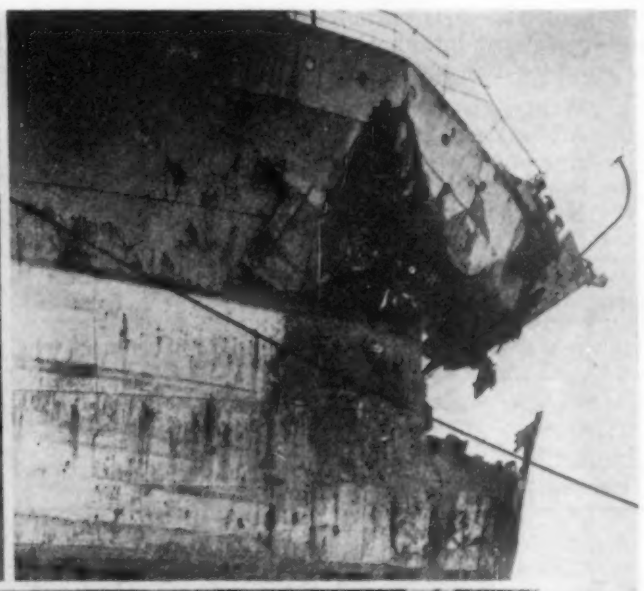


Fig. 10



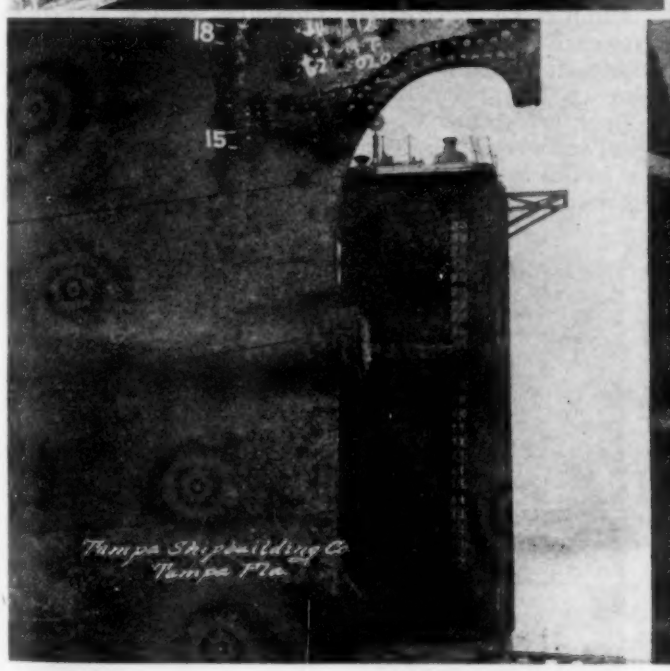



Fig. 11

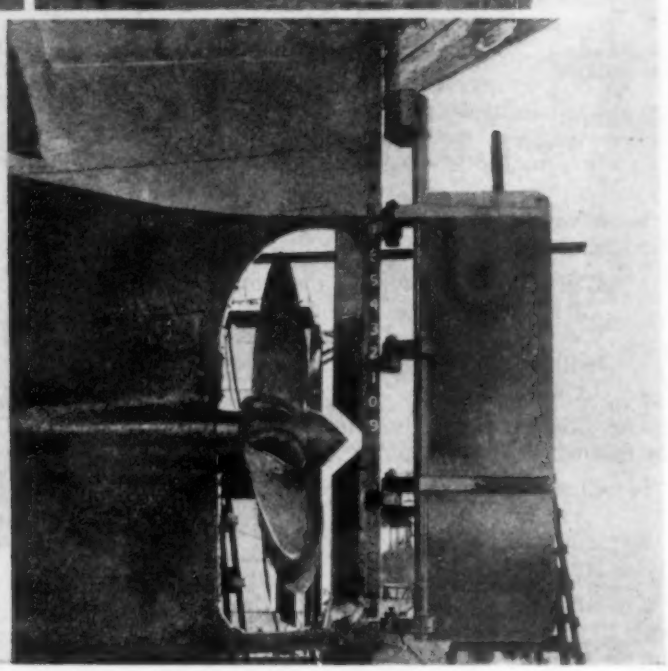


Fig. 12

Fig. 9—Interior View of Torpedoed Vessel Later Repaired by Welding
Fig. 10—Bow of Torpedoed Vessel Rebuilt Largely by Welding
Fig. 11—Stern Frame Damaged by Shell Fire
Fig. 12—Stern Frame and Rudder of Vessel Shown in Fig. 11 Repaired by Welding

this subject, and it appears that each yard should attempt to train for their own individual wartime needs. Evidently, the standard welding course, covering welding in all its phases, should be disregarded during the present emergency.

*Welding Equipment and Supplies*

Setting up specifications for necessary welding equipment is another important function of the Welding Control Center. The protection and maintenance of this equipment, after it has been put into use, is likewise a vital sequence. The conservation and control of strategic materials, such as welding electrodes, oxygen, acetylene and calcium carbide, is so critical that the War Production Board is insisting that a monthly report be made as to stocks on hand, consumption and estimates of future consumption. The manner in which one shipyard controls welding electrodes is shown in Fig. 13.

In each rod distribution room, a clerk gathers the following daily information and records it on forms prepared for that purpose:

1. Welder's badge number and shift.
2. Amount and size of rod issued.
3. Amount of rod returned.
4. Stubs returned.
5. Hull or job number.

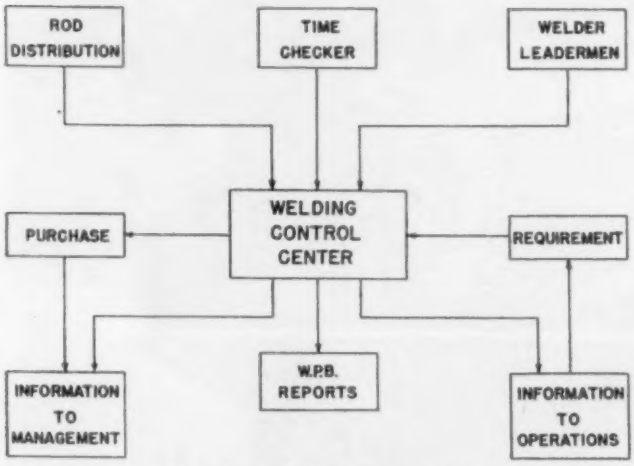



Fig. 13—Welding Control Chart

Each welder leaderman in turn makes out a daily check sheet showing:

1. Welder's badge number and shift.
2. Tacking hours.
3. Welding hours.
4. Hull or job number.
5. Type of work.

The time checkers give the Welding Control Center the following:

1. Classification of employee (welder, learner, trainee, etc.).
2. Hours worked daily or weekly.
3. Hull or job number.

The above information from the three sources is then sent to the Welding Control Center where clerks (in the ratio of one clerk to 500 welding department employees) sift this information and compile the following data.

*To Management.*—A weekly welding summary, showing the percentage of welding done on each hull under construction, the cost per pound of deposited weld metal and a general check of the ratio of supervision, tacking, and production welding.

PROCEDURE NO. 17
HULLS - 70-101

WELDING ENGINEERING DEPT.

1. TITLE :
2. REFERENCES :
3. LOCATION OF JOB :
4. ERECTION AND WELDING SEQUENCE :
5. SPECIAL WELDING PROCEDURE :
6. GENERAL WELDING NOTES :

DATE _____ APPROVED _____
WELDING ENG'R.

Fig. 14—Outline of Welding Procedure As Issued to Operating Divisions

*To Operations.*—A daily report on individual operators who use less than a certain predetermined amount of welding rod while welding or tacking or who consistently turn in stubs longer than 2 in. In compiling this report, the leaderman under whom they work is included.

In this manner, the report gives those in authority a partial check on the efficiency of the leaderman.

A weekly report to operations, showing per cent completion of all hulls, over-all stub losses, stubs reclaimed and pounds rod per man-hour.

Reports for regulatory bodies such as the War Production Board, the American Bureau of Shipping or the Navy Department, are readily obtained from the above information.

*Welding Procedures*

Written welding procedures, giving step-by-step information to the men building each subassembly, structure, etc., are fast becoming a recognized necessity. In some shipyards, it is now the general practice to issue: first, a general welding procedure for each type of hull to be constructed; second, a welding procedure for each structural drawing; third, a welding procedure for each subassembly; and fourth, a procedure for uniting the various subassemblies on the ways or slabs. These procedures are issued to the leadermen, foremen and supervisors on the job.

In this manner inexperienced ship fitters can be sure of fabricating the various sections as nearly free of residual

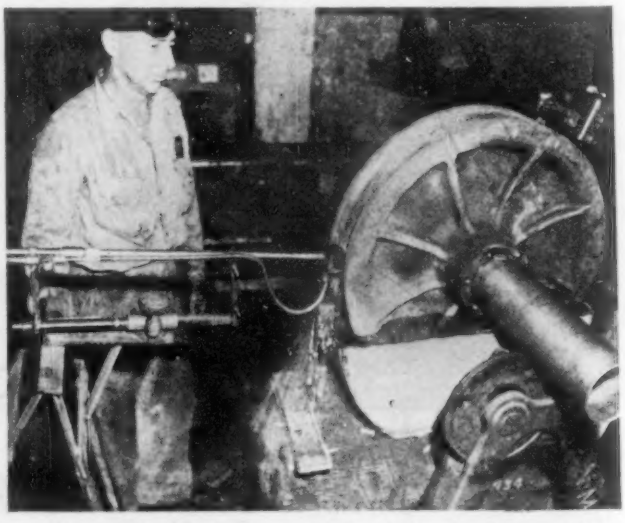


Fig. 15—Flame Hardening a Gantry Wheel with Improvised Equipment

SULPHUR PRINTING

1. SOAK PHOTOGRAPHIC ENLARGING PAPER IN A 2% SULPHURIC ACID SOLUTION.
2. GRIND METAL SPECIMEN SMOOTH.
3. PLACE THE METAL SPECIMEN ON THE WET PROCESSED PAPER. SEE THAT GOOD CONTACT IS MADE BETWEEN PAPER AND METAL.
4. ALLOW CONTACT FOR 2-3 MINUTES.
5. REMOVE SPECIMEN AND FIX PAPER IN A FIXING SOLUTION FOR 15 MINUTES.
6. REMOVE FROM FIXER AND WASH IN RUNNING WATER FOR 30 MINUTES.
7. REMOVE PRINTS FROM WASH AND DRY. GLOSSY PAPER SHOULD BE DRIED ON A FERROTYPE PLATE.

Fig. 16

NICKEL

1. CLEAN A SMALL AREA ON METAL SPECIMEN.
2. APPLY TO CLEANED AREA TWO DROPS OF A SOLUTION OF 100 cc. NITRIC ACID; 25 cc. SYRUPY PHOSPHORIC ACID (85 %); 125 cc. $H_2O$. ALLOW 10 SECONDS REACTION.
3. BLOT WITH CLEAN UNTREATED BLOTTER. APPLY TO SAME SPOT ON BLOTTER ONE DROP OF A SOLUTION OF - (A) 1 gm. DIMETHYLGLYOXIME DISSOLVED IN 60 cc. CON. GLACIAL ACETIC ACID, (B) 10 gms. AMMONIUM ACETATE DISSOLVED IN 30 cc. AMMONIUM HYDROXIDE (0.90 S.G.), POUR (A) INTO (B).
4. FROM THE STAIN ON THE BLOTTER —

| COLOR | INDICATION |
|---|---|
| PINK | 1-1.5 % NICKEL |
| RED | 3.5-5% NICKEL |
| CARMINE | 18-8 STAINLESS |

Fig. 17

CHROMIUM

1. CLEAN A SMALL AREA ON METAL SPECIMEN.
2. APPLY TO CLEANED AREA ONE DROP OF A SOLUTION OF 1 PART NITRIC ACID, 1 PART HYDROCHLORIC ACID, 2 PARTS $H_2O$ ALLOW COMPLETE REACTION BLOT UP SOLUTION AND DISCARD BLOTTER.
3. PUT TWO DROPS OF A FRESHLY PREPARED SATURATED SOLUTION OF SODIUM PEROXIDE IN $H_2O$ TO ETCHED AREA. ALLOW 15 SECONDS REACTION.
4. BLOT WITH CLEAN UNTREATED BLOTTER. PUT TWO DROPS OF A SATURATED SOLUTION OF BENZIDINE IN 50 % ACETIC ACID ON THIS BLOTTING.
5. A BLUE STAIN WILL INDICATE THE PRESENCE OF CHROMIUM. THE INTENSITY WILL INCREASE WITH THE CONTENT.

Fig. 18

stress as possible. The old, well-known rule of welding butts of sections with one member free to move, becomes much clearer to the man on the job when he has instructions in black and white, rather than verbal utterances in his head.

An outline of a welding procedure, as described above, is shown in Fig. 14.

COPPER-NICKEL ; NICKEL-COPPER

1. CLEAN A SMALL AREA ON METAL SPECIMEN.
2. APPLY TO CLEANED AREA ONE DROP OF A 50 % NITRIC ACID SOLUTION. ALLOW 15 SECONDS REACTION. CAUTION MUST BE TAKEN TO ALLOW NOT MORE THAN 15 SECONDS REACTION OR THE RESULTS WILL BE THE SAME FOR BOTH METALS.
3. TAKE UP SOLUTION ON CLEAN UNTREATED BLOTTING PAPER.
4. APPLY TO THE SPOT ON BLOTTER TWO DROPS OF AMMONIUM HYDROXIDE.
5. IF A BLUE STAIN APPEARS ON THE BLOTTER THE MATERIAL IS COPPER-NICKEL.
6. IF NO STAIN APPEARS THE MATERIAL TESTED IS NICKEL-COPPER.

Fig. 19

MOLYBDENUM

1. SOAK AND DRY UNTREATED BLOTTING PAPER IN A 10 % AQUEOUS SOLUTION OF POTASSIUM ETHYL XANTHATE.
2. CLEAN AN AREA ON METAL SPECIMEN AND APPLY ONE DROP OF 50 % NITRIC ACID.
3. ALLOW REACTION TO COMPLETE, BLOT WITH UNTREATED BLOTTER AND DISCARD BLOTTER.
4. APPLY TO ETCHED AREA ONE DROP OF A SOLUTION OF 1 PART SULPHURIC ACID IN 5 PARTS $H_2O$. ALLOW 15 SECONDS REACTION.
5. BLOT WITH TREATED BLOTTING PAPER. A RED STAIN WILL INDICATE THE PRESENCE OF MOLYBDENUM. THE CONTENT WILL GOVERN THE INTENSITY OF THE STAIN.

Fig. 20

In the case of shipyards working with drawings designed outside of the yard, it is also necessary for the Welding Control Center to carefully check each drawing, in order to determine that the yard concerned is equipped to fabricate in the manner therein noted, and to check for correct joint design, accessibility, etc.

*Allied Processes*

There are various allied processes which go hand in hand with welding and cutting. The Welding Control Center should determine which of these processes are necessary to operation of the individual yard. Some such processes are flame hardening, flame descaling, metal spraying, stud welding, X-ray and magna-flux inspection, resistance welding, silver brazing, shape cutting, stress relieving and various automatic welding processes.

Figure 15 shows the flame hardening of a gantry crane wheel, using a portable cutting machine carriage, a large blowpipe and a special home-made heating and quenching head.

*Coordination*

Probably the most important function of the Welding Control Center is coordinating with the various operating divisions of the shipyard and doing the necessary missionary work in introducing new equipment and methods of operation so that ships may be built more efficiently. Old timers in the shipbuilding industry are today accepting with interest and good will, all

phases of welding and cutting. When foremen and supervisors learn that there is a definite place to go with their welding or cutting problems, their work becomes more simplified and the final product is improved.

Another part of this coordination is the test and inspection of materials and finished welding. Knowing the reasons for weld failures and methods of correcting them pays big dividends.

The necessary equipment for a small laboratory to make chemical analyses may be obtained at a cost not to exceed $1000. However, without this equipment, certain non-destructive tests may be made in the field to determine the presence of harmful elements. Spark tests for determining the carbon content of steel are widely known, and this method of testing the carbon content is sufficiently accurate for most practical purposes.

Some elements or combinations of elements, such as nickel, copper-nickel, nickel-copper, molybdenum, chromium and phosphorus are easily detected in the field by Spot Testing. Sulphur and phosphorus segregations may be satisfactorily determined by means of prints made on ordinary photographic paper. Procedures for making such spot tests and prints are shown in Figs. 16 to 20.

To give some examples of the use of the above tests: recently some trouble developed at a certain shipyard in the welding of certain spacing and retaining rings in a stern tube. Each time the ring was welded the fillet weld would crack. By spot testing, it was found that this was a high-nickel alloy steel which had inadvertently been used in place of the mild steel specified.

Another instance was the Unionmelt welding of three plates to form a deck section of a vessel. After welding, transverse cracks were found approximately every half inch of the three welded joints. Spark testing showed high carbon and subsequent chemical analysis showed a carbon content of 0.46. Upon making a sulphur print of a cross section of the weld, a facsimile of which is shown in Fig. 22, sulphur segregations were found which had apparently carried into each crack of the finished weld. The spot test for molybdenum is more than useful in the pipe shop where it is quite possible for carbon-molybdenum pipe to become mixed with mild steel pipe.

SULPHUR PRINT
( FACSIMILE )

Fig. 21

*Conclusion*

The purpose of this paper, as stated before, is not to deal with any specific problem of welding in shipbuilding, but to try to point out the functions of and the necessity for a well-planned Welding Control Center in each shipyard.

It is mandatory that the individual in charge of such operations be given sufficient authority to carry out his recommendations, and to see that they are followed as closely as possible by the productive units concerned.

The far-reaching use of welded construction, involving many problems heretofore unsolved, makes it imperative that a competent person, or persons, continually investigate and supply the information necessary to correctly use new methods and applications. This is particularly true at the present, due to inexperienced operators and to the use of substitute materials resulting from wartime necessity.

Setting up such a department as outlined cannot help but benefit any shipyard and smooth out a considerable number of their welding problems.

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# Comments on "Structural Failures in Welding Ship Construction"*

By M. H. MacKusick†

PARAGRAPH two under subheading "Stress Concentrations" reads as follows:

> "Since the transverse section of a ship is the cross section of a huge box girder, it is evident that the four outboard corners of the section—the gunwales and the bilges—constitute especially critical points. Appendages such as bilge keels, or other secondary parts (for example, bulwarks, water way bars and hatch coamings), once they are joined to the main material at its extreme fibers, actually behave as part of the main structure, regardless of their intended secondary structural importance. Their details and workmanship, especially in critical areas, are very important."

It is the opinion of the writer that in the conventional cargo ship the midship deckhouse also forms, in effect, a secondary box girder which is superimposed on the main box girder formed by the hull structure itself. In the case of the Liberty Ship most yards weld the main deckhouse sides to the stringer plate of the upper deck, hence the two box girders become a welded unit. In effect, we have a main girder with a secondary girder superimposed in the central part where working stresses under load are at a maximum. No provision is made for continuity at the four corners of the deckhouse, hence the working stresses under load which exist in the deckhouse part of the structure must concentrate at the corners of the house. Several Liberty Ships have fractured under service loads immediately forward or aft of the main deckhouse structure, and these failures may well be due to excessive working of the main deck plating at the corners.

It is suggested that longitudinal continuity in way of the deckhouse corners could be improved by providing

(*Continued on page 243*)

* Published in the December, 1943 issue of THE WELDING JOURNAL, p. 980.
† Welding Engineer, California Shipbuilding Corporation.

# Field Welding of Steel Penstocks and Tunnel Liners*

By L. G. Christofferson†

ONE very interesting thing about erecting the penstocks, tunnel liners, surge tanks and risers on hydroelectric power plants is that the welding problems are of a very special nature and require widely varying procedures and equipment to obtain satisfactory results. In recent years I have had the good fortune of being directly connected with the erection of nine such projects in the capacity of Field Erection Engineer. The views, statements and conclusions which I am about to present are mine—not necessarily those of my company—and are based on my experiences on these various projects. I sincerely hope that they will be of help and interest to you.

The welding problems can be discussed with reference to two operations, the first of which is the welding of the plates into single or multiple ring sections in an assembly yard adjacent to the erection site, and second of which is the welding together of these sections in their final positions.

## Assembly Yard Welding

Whenever the volume of work is sufficient at one location to warrant the use of an automatic welder, it has very definite advantages both as to cost and quality of work. In fact, most of the recent specifications on this class of work require machine welding of all longitudinal joints.

The two most commonly used automatic processes are the carbon arc and the submerged melt. In plate thicknesses up to about $^3/_4$ in., the carbon arc welder with only two passes will do a very satisfactory and economical job meeting the A.S.M.E. and A.P.I.-A.S.M.E. requirements for unfired pressure vessels. The welding causes very little distortion. Abutting edges are in contact and square. The best results are obtained with the work on a slight slope and the welding done uphill. Although machines of the tractor type are available the welding of longitudinal joints with the rings stationary is difficult, because the tractor must travel up the incline to perform the welding. Therefore, it has been our practice to support the carbon arc welder on a boom and to move the work past the stationary machine. Quite an elaborate piece of equipment is required to handle the large diameter rings of pipe on the slope at the required speeds for the welding. The unit must have variable speed control to suit the different thicknesses. D.-c. generators supply the current for the common type of carbon arc welder.

In welding plates over $^3/_4$ in. thick by the automatic carbon arc process it is necessary to use a combination square butt and grooved joint and to do the welding with more than two passes. After the first pass on the groove side is completed, a filler rod of the same composition as the plate is tacked in the groove prior to welding the next pass. As this involves making more than one pass at least on one side of the joint, and also a delay while the filler rod is tacked in place, the submerged arc process is much faster, does not require that the work be on an incline and with the tractor type machines the longitudinal joints are readily welded while the rings are stationary. On heavier than $^9/_{16}$-in. thick plate a double-vee tight butt-grooved joint with a wide root face is used. The outstanding advantage of the submerged melt process, as compared with the carbon arc process, is its ability to weld up to $2^1/_2$-in. thick plates in two passes with a 2000-amp. machine. With special care in establishing and using the correct procedures, welds of the highest quality are obtained. Here again the shrinkage and distortion due to welding are very small.

It is our common practice on longitudinal joints to weld the inside first and then weld the outside. By doing it in this manner we find that only in special

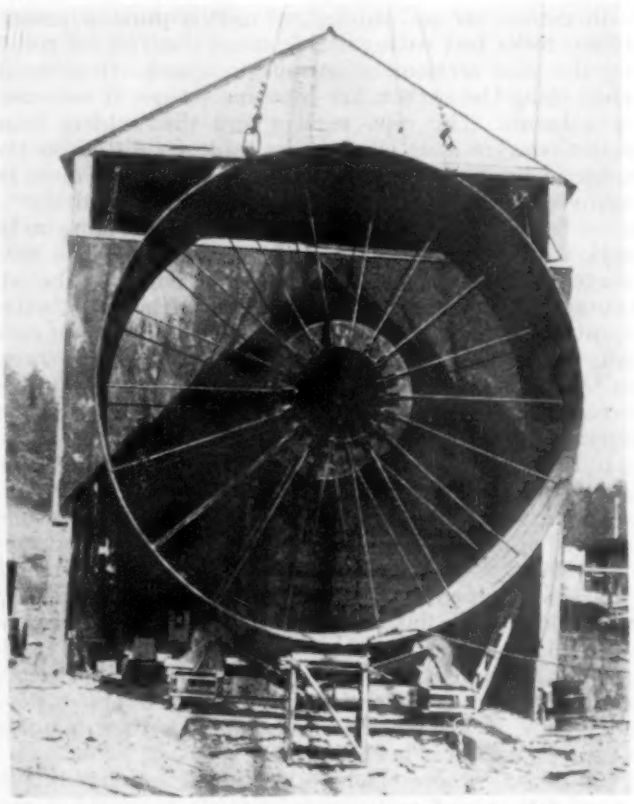


Fig. 1—Removing a Completely Welded Ring of 18 Ft. Diam. Pipe from Roller Bed After Machine Welding of Longitudinal Joints by Submerged Melt Process Inside Building

* Presented at the Annual Meeting, A.W.S., Chicago, Ill., Oct. 18 to 21, 1943.

† Field Erection Engineer, Chicago Bridge and Iron Co., Chicago, Ill.

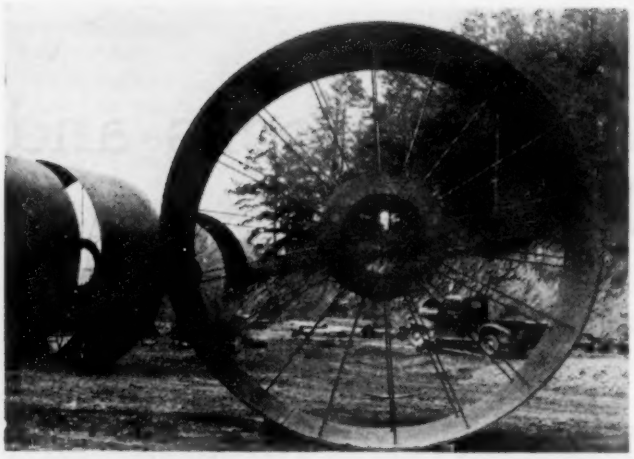


Fig. 2—8 Ft. Long Ring of 18 Ft. Diam. Pipe Fitted and Ready for Machine Welding of Longitudinal Joints. Notice Joint in Lower Left Hand Portion. Inside Is Cleared for Welding. All Fitting Gadgets Are Outside

cases special measures need be taken to prevent distortion, and the completed joints are smooth and make a very uniform circumference. Start and stop plates are required on the ends of the longitudinal joints that are to be machine welded. The start plates are used to start the weld and get the machine in correct adjustment before the actual welding on the joint begins.

The stop plates allow the molten puddle to carry on far enough to insure a 100% completed weld at the end of the plate, and also put the finish crater out on the stop plate. In the heavier plates these stop plates should be grooved, and in very heavy plates there is a definite advantage in having them made from two grooved plates fitted together, just as the pipe ring plates are fitted.

The machine welding of circumferential joints with both carbon arc and submerged melt requires a power-driven roller bed with variable speed controls for rotating the pipe sections at a uniform speed. Here again when using the carbon arc machine we use it mounted on a boom. The pipe rotates and the welding head is stationary. This is an undesirable condition on the inside of the pipe because the stiffening spiders must be removed to allow the boom to enter the pipe and also to allow the pipe to rotate. A much better solution can be worked out using a tractor type machine. The submerged melt machine that is tractor driven has the advantage over the carbon arc machine in that it is better adapted to welding all thicknesses with one pass on each side. It can be put inside the pipe and allowed to travel on the plate. This is done by rotating the pipe in one direction and by having the welding head traveling at the same rate in the other direction.

If the size of the job does not warrant the installation of an automatic machine then this assembly yard work can be very nicely handled on roller beds either powered or rotated by manual or semi-mechanical means. In either case the work can be expedited and welding difficulties reduced to a minimum since all the welding can be done in the flat position which facilitates the use of larger electrodes.

In all machine welding, procedure is the main feature because watching the actual welding and operator does not enable an inspector to determine whether or not a satisfactory weld is being made.

On all jobs where machine welding is employed, it is essential that trial test plates be made to establish the procedure before production welding starts, and that the qualified procedures be recorded. After these test plates are given the required physical tests with satisfactory results, one can be quite certain that the same procedure will produce the same quality of weld over and over again—all of the other factors being the same. Of course, if procedures are already established for all of the plate thicknesses and types of joints, then the results of test plates made at regular intervals will give assurance that the established procedures are being followed.

While the welding is in progress, a view of the joint on the opposite side will enable the operator's helper to determine whether or not the welding is being performed directly in the groove, and to some extent the degree of penetration as indicated by the discoloration.

Inspection of etched cylinders trepanned at regular intervals at random locations in the joints is very helpful in judging the quality of the weld and keeping operators "on their toes."

Of course, on jobs where X-ray or gamma-ray examination is used, the necessity of trepanning inspection is entirely eliminated and the number of production test plates required can be cut down to a minimum.

It is common in current specifications to require that all sections be given a hydrostatic test to $1^1/_2$ times the design stress. Since only the longitudinal joints are highly stressed, we don't feel that it is necessary to test built-up sections 16 to 24 ft. long when the test is primarily a test of the longitudinal joints. We have, therefore, advocated that the individual rings be given a test rather than the built-up sections. There is no reason why the assembly yard welded girth joints should be given a hydrostatic test to $1^1/_2$ times the working pressure when the girth joints welded in place are not tested to the same pressure. In none of 650 rings of 12,

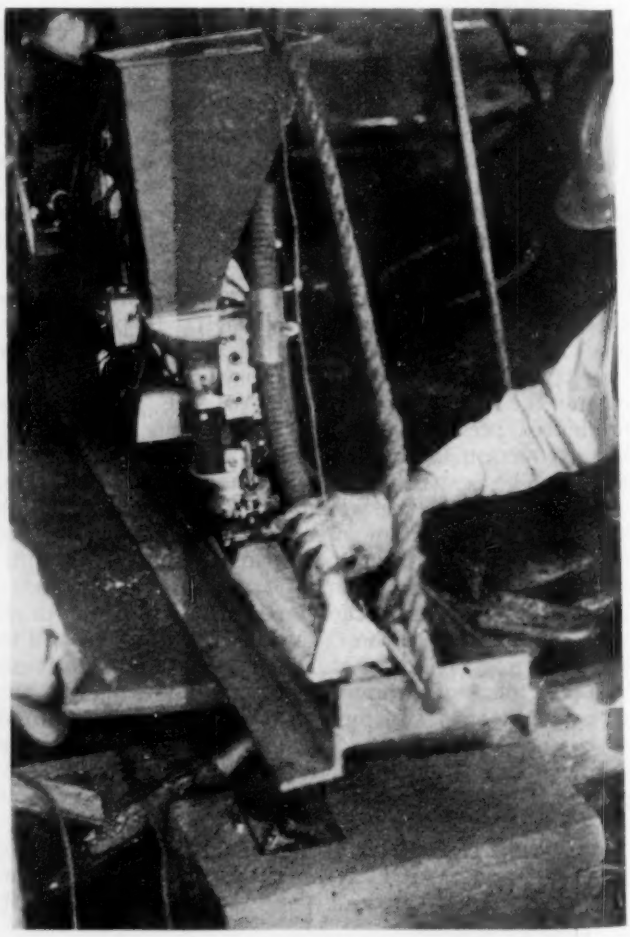
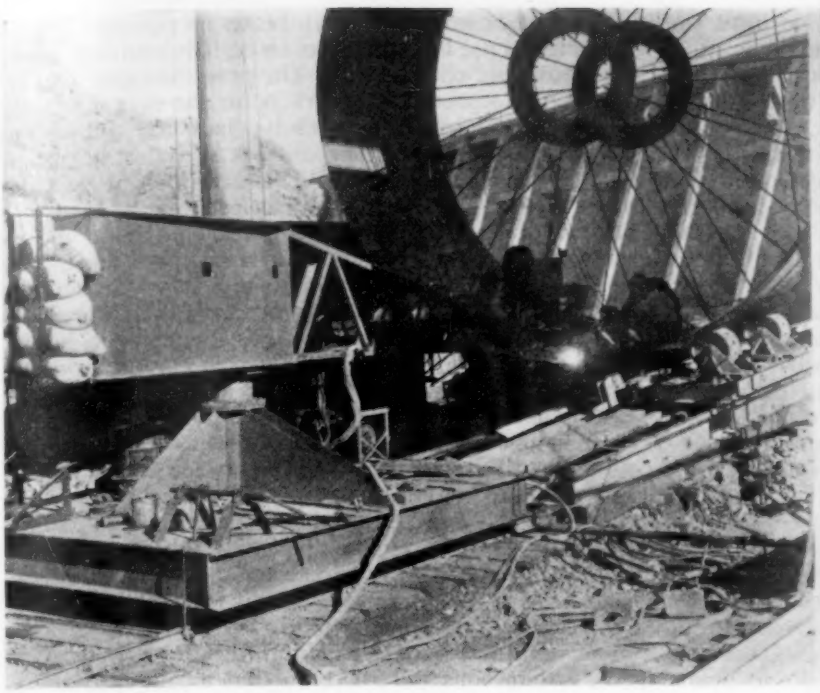


Fig. 3—Submerged Melt Welding of Inside of Longitudinal Joint in 18 Ft. Diam. Ring. Notice Machine Travels on Track



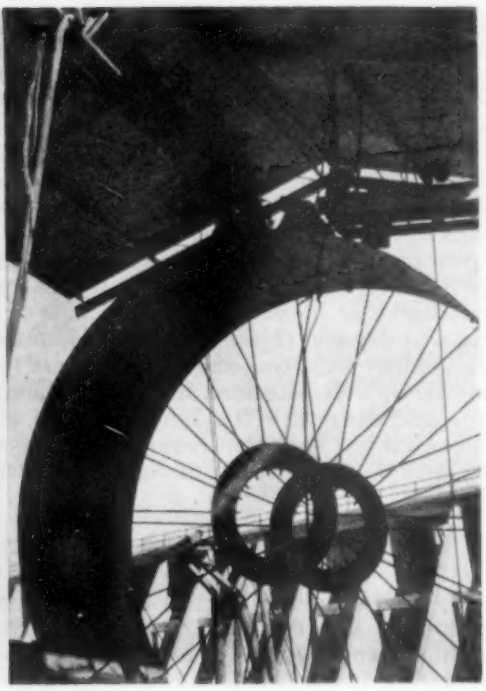


Fig. 4 (Left)—Automatic Carbon Arc Welding Machine with Boom in Lowered Position Welding the Inside of a Longitudinal Shell Seam. Notice Worm Drive Shaft (Midway Between the Rails on the Inclined Ramp) Which Controls the Speed of the Carriage as It Travels Down the Ramp

Fig. 5 (Right)—View of Automatic Carbon Arc Welding Machine on End of Boom in Raised Position Ready to Weld the Outside of a Longitudinal Shell Seam. Notice Rolling Sunshade in Place Over Entire Setup.

14, 16 and 18 ft. in diameter pipe, which we have tested in the last few years to $1^1/_2$ times the working pressure, have we found a leak or any indication of a structural weakness. The longitudinal joints were all double welded with the submerged melt process. As a result, we are of the opinion that such testing especially where X-ray examination is used, is unnecessary.

At various sections where pipe sections are encased in concrete and where the pipe requires external stiffness, it is necessary to weld either plate or built-up stiffeners around the outside circumference of the pipe. This can most easily be handled after the longitudinal joints are welded and weld examination and testing operations are completed. With the ring placed on the ground with its axis vertical, the stiffeners are fitted in place and regular tacks put in overhead. The top side of each stiffener is then welded manually, doing all welding in the horizontal position with large electrodes. After all the welding is completed on the top side of the stiffeners the ring is turned completely over and the welding on the other side is completed in the same manner. This method has two main advantages—first, it expedites the work by doing the welding in the horizontal position using large electrodes, and second, it insures a better looking job which can be made with second-rate operators leaving the best operators for work on the main shell seams.

It is usually necessary in most pipe lines to weld several segmental rings into elbow sections. Since they are irregular in shape they do not lend themselves very well to machine welding of the girth joints, it becomes necessary to manually weld these joints to make a multiple ring elbow section. We have tried several methods for doing this and the one finally decided on is as follows: first, the joints are double beveled for welding from both sides, then the rings are fitted together with their axes horizontal. The bottom halves of the joints are manually welded on the inside at the same time the top halves are being welded outside. The section is then rolled over and the unwelded portions are then back chipped and welded in the flat position. This procedure makes most of the welding in the flat and sloping positions with a little vertical, and entirely eliminates the overhead welding.

Our experience with the various types of equipment indicates the following defects are most prevalent. With carbon arc and submerged melt welding the most trouble was encountered with scattered and straight line porosity which we are able to attribute to moisture, dirt and rust on tight-fitting square butt joints. On submerged arc welding undersurface cracks often occur if the correct procedure is not adhered to. The most common of these undersurface cracks are caused by welding with too high voltage. They are difficult to detect in that they do not come to the surface and are most easily found with X-ray examination. Manual welding may develop any and practically all types of defects, but on penstock work where 100% weld is required and considerable chipping and cleaning are required, the main defects that are encountered are lines of non-fusion at the root, or scattered slag. It is characteristic of all types of machine welding to leave lines of non-fusion whenever the welding head gets a little out of line with the joint, or when the operator lets the current drop too low to get the required penetration.

In a field assembly yard it is very difficult and usually impractical to weld joints as fast as they are fitted. It is also quite impractical to provide shelter for sections and as a result they often get damp before they are welded. This damp condition, together with the rust that goes with it, is the cause most of the time of the porosity in the machine weld. A small heating torch just preceding the welding head will remove the dampness and clean down in the groove where a power brush will not reach.

We find it desirable to do all fitting on machine- and hand-welded joints on the opposite side from the side to be welded first. All the necessary gadgets required to

fit the joint are left in place on the outside until the inside is welded. By proceeding in this manner, it is unnecessary to put tacks directly in the groove when the joint is fitted. Thus it is possible to weld both sides in a clean groove free of fitting gadgets or tacks.

We have done some position welding with both d.-c. and a.-c. machines using a heavily coated electrode of the E6011 classification. We have obtained very good results on heavy plates after we were able to convince the operators that good work could be done in all positions with this type electrode. On X-ray work for heavy plates we found that the exographs were much cleaner and that less cleaning and chipping were required than on similar work where light-coated electrodes were used with d.-c. machines. We also found that the training period for new operators with the heavily coated electrodes was somewhat less than that required on our standard welding with d.-c. machines and light-coated electrodes.

### In Final Position Welding

We might divide this class of welding into groups according to the thickness of the plate involved. From $2^1/_2$ in. down to about $1^3/_4$ in. there seems to be a decided advantage if the penstock can be preheated and maintained at a medium temperature until most of the welding is completed. The preheating can most easily be done and controlled by electrical induction using single-phase transformers to supply the current. This equipment when connected with an automatic controlling pyrometer does a nice job of keeping the pipe at a uniform temperature.

Because of the magnetic effect of the current passing through the coils, welding operators will experience, on joints thus preheated, considerable trouble welding joints in thick plates after the first one or two passes. The first pass goes in very well and also the second. The magnetic effect seems to pull the metal into place and fuses it well to the side walls of the groove. As the groove widens out it becomes a little more difficult to manipulate the electrode, but we soon found out that better results were achieved by setting the current on the preheating transformer at the correct amount for continuous heating rather than by building up to a high temperature and then cutting out until the pipe cooled down to the minimum temperature. After the operators accustomed themselves to welding while the current was on in the heating coils they continued with very good results.

We found that with preheating one bead could be deposited continuously around the joint without any danger of cracking. It worked much better on pipe up to 12 ft. diameter to use two operators on a girth joint, one working inside and one outside. The procedure most readily adaptable to production work is for the man inside the pipe to weld the overhead or top half first and for the one on the outside of the penstock to weld the bottom half or the overhead first. This is true of at least the first three or four passes. When each operator has deposited four passes, then the chippers chip down into the root of the weld on the top half of the pipe outside and the bottom half inside. This makes all of the difficult chipping in the flat or sloping position. Since the back chipping is done in these positions, the chippers have a much better chance of doing a good job than they would if chipping overhead.

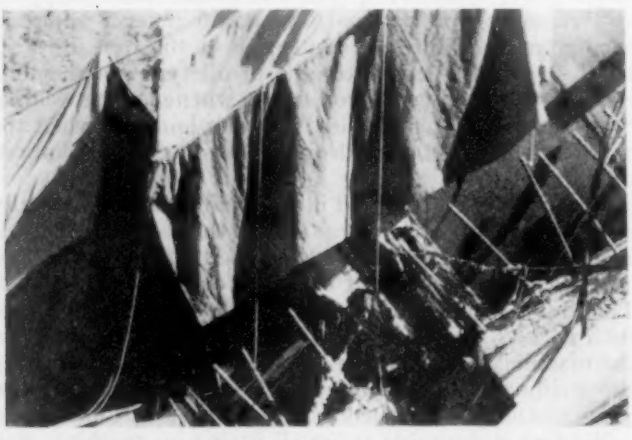


Fig. 6—View of Joint of 8 Ft. Diam. Penstock Pipe with Preheating Coils Installed. Material 2 In. Thick. Notice Canvas Shelter to Protect Heated Joint from Rain

The inside operator then welds four passes in the bottom half inside and the outside operator welds four passes in the top half outside. At this time the joint has a total of eight passes deposited in it all around the circumference and the need for the preheating is considerably decreased so the pipe is gradually cooled to about 150° while each operator deposits his fifth continuous pass. The preheating unit is then disconnected from that joint and connected to the next joint, which is already outfitted with coils and the proper insulation. Two sets of coils were used so that a joint was always ready ahead of the welding. While the operators were depositing the last two passes the next joint was being preheated so that it would be hot and ready for the operators by the time the weld on the first joint was built up flush with the plate but still short the reinforcing bead. The two operators then moved right up to the next joint and started the procedure all over again. Following along behind them was a third operator who did nothing but weld the finish or reinforcing layer. After a few joints he became very skilled and made a very nice appearing weld which very seldom needed any chipping or grinding before the joint could be radiographed satisfactorily. Since it takes quite a little time to heat a joint, also lots of electricity, the welding and preheating operation had to be continuous 24 hr. a day. Two operators were worked on each shift and on the day shift the third operator was used to weld the finish beads and repair any defects discovered in the radiographs.

On plates from $1^3/_4$ to $1^1/_4$ in. thick for which stress relieving is usually specified but is impractical, we find that setting up and following the same general procedure as outlined above will yield good results and not cause cracks if the first four passes are deposited one on top of another in short lengths thereby keeping the weld and plate warm. This is known as cascading. When preheating was used, one pass could be deposited continuously without cracking. On this thickness of plate, without preheating, three or four cascaded passes give reasonable assurance that the weld will not crack. Strict adherence to the correct procedure will produce welds which will yield very fine radiographs free from defects except those due to insufficient chipping or slag.

On material $1^1/_4$ in. thick and down to about $^3/_4$ in. thick, we do our welding without preheating, using the cascade method for the first two or three passes only, and on lighter than $^3/_4$-in. thick material, continuous single passes can be laid without cracking.

When a long line of penstocks or other pipe is being erected another main problem is that of keeping the pipe in its proper alignment. To do this requires a welding procedure that will keep the shrinkage uniform all around the circumference of the joint. The welding if not performed in the proper sequence will shrink more in one place than it does in another and consequently change the location of the free end of the penstock

either horizontally or vertically depending upon where the incorrect procedure is used.

This condition when it exists is very undesirable, because in order to set the next section in its proper place the joint to be welded must be wide at one place and narrow at another. The wide spots will draw more than the narrow ones and it is hard to get the pipe and welding properly lined up to where the production is again traveling at its normal rate.

In connection with most high-head power plants there is a surge tank connected to the tunnel below with a steel-lined surge tank riser pipe. At the connection between the steel tunnel liner and the surge tank riser is required a built-up steel tee. This tee is under high pressure and must be designed to withstand all of it where the earth or rock surrounding the tunnel cannot be depended on for any strength.

An inside web or tie could be provided to keep the tee in shape but since it would restrict the flow, it is desirable to provide reinforcement outside. This is often in the form of an external forked ring girder wholly or partly encircling the tee.

A built-up tee of this type has many complicated welded joints and requires stress relieving. On a job where no other stress relieving is required it is quite impractical to set up a furnace to stress relieve this one piece; we have, therefore, had these tees built up in our shop and stress relieved there. Then, if they could be shipped in one piece to the destination, this was done. If not, they were cut in two pieces which could be shipped. Of course, the cut was made at a location where the final welding would encounter only direct shrinkage and there would be a minimum of locked-up stresses due to complicated joints. After the tee was received and completed on the job, hemispherical bulkheads were welded to the three openings and it was given a hydrostatic test to $1^1/_2$ times the working pressure.

Occasionally we still encounter a job where the designers do not rely on welding for strength and specify riveting and caulk welding together. This always involves many hair-raising experiences, because if the caulk welding is done first, it will usually crack while the rivets are being driven. If the riveting is done first, then the welding will invariably loosen some rivets. We are directly opposed to this combination as the two do not mix and attempts to mix them usually result in making a full fillet weld instead of a caulk weld and when this is done, the welding carries most of the stress in the joint, very little of it getting to the rivets.

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# Granite and Steel Products Move Off War Production Lines in Unusual Plant Conversion

By A. F. Davis*

ONE of the most interesting cases of American industry's conversion to wartime production was recently reported to The Lincoln Electric Company, Cleveland, Ohio, when they received word that the Cold Spring Granite Co. of Cold Spring, Minn., is now turning out welded engine supports, ship plates and anchor chains for the nation's giant shipbuilding program.

In the company's huge plant, originally designed to produce stone products such as monuments and mausoleums, granite and welded steel products now move side by side along production lines. Inasmuch as the plant was equipped with several heavy duty traveling cranes, suitable grinding equipment formerly used to shape granite blocks and other suitable facilities, the conversion presented no real problem to the management. The grinding equipment, for example, is now used to bevel plates prior to welding with the result that excellent fitup is obtained.

Most of the company's 400 employees now working with steel received their training through courses in arc welding, metal shaping, pattern making and kindred subjects given by state and federal instructors. Procedures have been worked out with the help of welding engineers of our Company.

Although the granite and the welded products have their own distinctive uses, they do have some things in common, according to company officials. Both have the qualities of strength and endurance that are recognized by all.

This interesting conversion was the subject of a recent write-up in the Minneapolis *Star Journal* in which the author said in part:

"The granite industry is a war casualty. Some old employees are still working on monuments and masuoleums, but in general the business has been closed down or converted to defense activity.

"Granite cutters here and at St Cloud are busy welding engine supports and ship plates. T. O. Benson of St. Cloud, tool sharpener to the granite industry for years, is turning out anchor chains. The Cold Spring Granite Co., is working around the clock to help arm the nation to beat the Axis, so that granite again will be wanted for new buildings.

"In the huge plant—designed by Albert Kahn, famous Detroit industrial architect—granite and steel move side by side along production lines. The granite comes in great blocks on railroad cars from the company's quarries at Rockville, Morton, Ely, and Ortonville, Minn., Mellen, Wis., Milbank, S. D., and Alhambra, Calif., though most of the quarries are no longer operating.

"Most of the 400 employees are working with steel. The change-over started last July. State and federal instructors gave courses in welding, metal shaping, pattern making and kindred matters. The local workers —many from nearby farms—were apt pupils, just as they had been in mastering the granite trades."

* Vice-President, The Lincoln Electric Company, Cleveland 1, Ohio.

# Arcless Current Interruption in Inductive D.-C. Circuits

By Charles W. Dodge,* John S. Stamm* and Nelson W. Spencer*

## Problems Involved in Interrupting Inductive Circuits

HIGH-speed interruption of a d.-c. current in a high-power inductive circuit has always presented a serious design problem. Probably the most outstanding example of this problem has been its application to electromagnetic stored energy resistance welding machines. This welding method is based on the principle of storing energy in a large reactor which has a primary and secondary winding on an iron core containing an air gap. A d.-c. voltage source (usually a few hundred volts) is applied across the primary winding of the reactor, giving rise to a charging current which increases exponentially. The steady state value reached by this current is directly proportional to the applied voltage ($E_p$) according to the equation $I_p = E_p/R_p$ where $R_p$ is the total resistance of the primary circuit.

While the primary current is increasing, it induces a voltage in the secondary winding which is proportional to the turn ratio and to the rate of change in $I_p$. This in turn produces a secondary current ($I_s$) (Fig. 1) which rises to a maximum value very quickly, then falls slowly to zero during the charge. In the welding machine, this induced secondary current is used as a preheat to prepare the weld metal for the high peak discharge welding current.

Actually, unlike the above illustration, the primary current is always interrupted before its steady state value is reached. This is accomplished by means of a contactor of special design between the d.-c. supply and the reactor. At a preset value of current, the primary circuit is opened

* Research Engineers at Sciaky Bros.

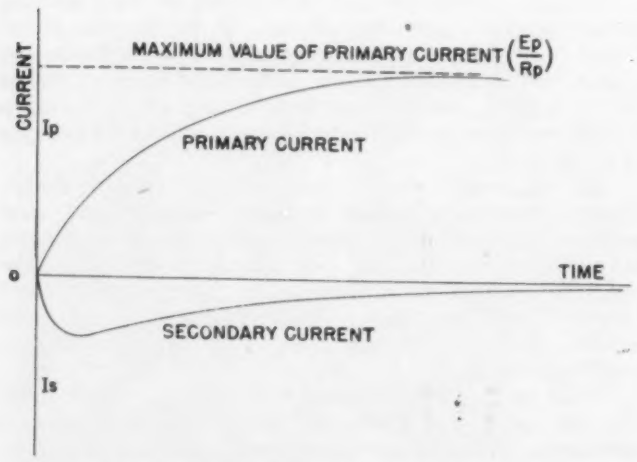


Fig. 1—Primary and Secondary Current Relationship in a Reactor with Primary and Secondary Windings from Zero Current to Full Charge in the Primary

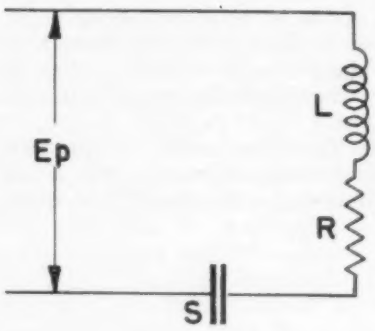


Fig. 2—Simple Inductive Circuit Components Consisting of Inductance ($L$), Resistance ($R$), D.-C Voltage ($E_p$) and a Contactor ($S$)

rapidly, which causes the energy stored in the reactor to be transferred to the secondary or welding circuit. During the short period of primary current interruption, the secondary current rises from the negative preheat to a very high positive peak, then falls to zero exponentially. The advantage of this system lies in the fact that the energy is accumulated slowly at a low power demand and is delivered to the weld rapidly at a high power output. In order to carry out the above process successfully, it is essential to use a current interrupting device which will give reliable and consistent performance and which can withstand the high electrical and mechanical stresses which are developed during the opening operation.

When a uni-directional emf. ($E_p$) is applied across a simple inductive ($RL$) circuit (Fig. 2), it will cause a current to rise exponentially according to the relation $i_i = E/R\ (1-\epsilon^{-Rt/L})$, and at any time ($t$) the energy stored in the inductance is equal to $^1/_2\,Li^2$. If this circuit is interrupted by opening the contactor ($S$), the energy stored in $L$ can only be dissipated in the arc which will appear across the contact points. The voltage across the contactor during opening is $e_A = -L(di/dt)$, where $di/dt$ is the rate of change of current.

By coupling a secondary circuit to the primary inductance, we are adding an additional method of energy dissipation.

Figure 3 illustrates a circuit consisting of primary resistance ($R_p$) and inductance ($L_p$) to which is coupled a secondary inductance ($L_s$) which in turn is connected to a non-coupled external inductive circuit of resistance ($R_s$) and inductance ($L_s$). The primary and secondary windings are coupled by means of the mutual inductance ($M = K\sqrt{L_pL_s}$) where $K$ is the coupling factor. In the case of a welding machine, $R_s$ and $L_s$ are the parameters of the throat of the machine, and $L_s$ represents the inductance of the secondary winding. Since a high turn ratio is used, the value of $L_s$ is much smaller than that of $L_p$, both windings enclosing the same magnetic circuit. Upon application of a d.-c. voltage to this

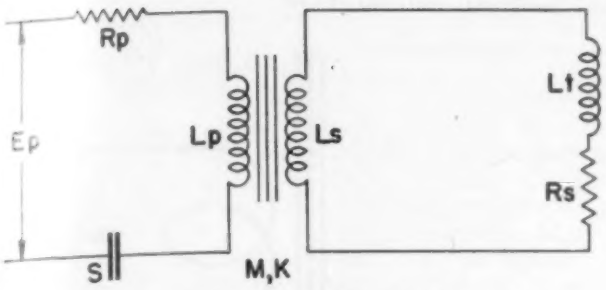


Fig. 3—Simple Coupled Reactive Circuit

circuit, the primary current will rise in a manner similar to the current rise of the previous circuit, being modified only by the effect of the secondary current (see Fig. 1). When the contactor ($S$) is opened, the energy which has been stored in the system is dissipated in two ways: (1) Most of it is transferred into the low impedance secondary circuit and gives rise to a current reaching a high peak value; (2) some of the energy is lost in the arc across the contact points.

It is of interest to determine the voltage and the energy dissipated in the arc. At any time during the opening of the contactor, the voltage distribution in the primary circuit is:

$$-E_p - L_p \frac{di_p}{dt} + M \frac{di_s}{dt} + R_p i_p + e_A = 0 \qquad (1)$$

and in the secondary circuit, the voltages are:

$$-M \frac{di_p}{dt} + (L_s + L_t) \frac{di_s}{dt} + R_s i_s = 0 \qquad (2)$$

A simple solution for the voltage across the contact points ($e_A$) can be found by assuming a linear rise of secondary current and by neglecting the voltage drops across the resistances since they are very small compared to the inductive voltages. (These approximations are valid provided the time of contactor opening is much less than the time constants of the circuits.) We can then solve these simplified equations and find:

$$e_A = E_p + L_p \frac{di_p}{dt}\left[1 - \frac{K^2}{1 + \frac{L_t}{L_s}}\right] \text{ volts} \qquad (3)$$

being the voltage across the contact points, and

$$W_A = {}^1/_2\, E_p I_p t_c + {}^1/_2\, L_p I_p^2 \left[1 - \frac{K^2}{1 + \frac{L_t}{L_s}}\right] \text{watt-seconds} \qquad (4)$$

being the total energy loss in the arcing of the contactor, where $I_p$ is the value of primary current at the instant the contactor begins to open and $t_c$ is the contactor opening time. In Equation 4 above, the first term represents the energy which is drawn from the power supply during the period of contactor opening. We are primarily interested in the second term which corresponds to the energy transferred from the reactor and which constitutes about 95% of the contactor losses. According to the above equations, this loss is independent of the time of contactor opening ($t_c$), while the voltage ($e_A$) across the contact points is nearly inversely proportionl to $t_c$. Both $e_A$ and $W_A$ are nearly proportional to the primary inductance and are profoundly affected by the term $L_t/L_s$ which is the ratio of the secondary throat inductance to the secondary core inductance, a value being generally about 0.20 depending upon the size of the welding machine. If in Equation 4 we substitute 0.20 for $L_t/L_s$ and let $K = 0.98$, we find by neglecting the first term that $W_A = {}^1/_2\, L_p I_p^2$ (0.23). Since the energy ($W_L$) stored during charging is approximately equal to ${}^1/_2\, L_p I_p^2$, the ratio $W_A/W_L = 0.23/1 = 0.23$; i.e., 23% of the stored energy in the reactor is lost in the arcing of the contactor. We see also that the inductance of the throat, which is necessarily of appreciable magnitude, acts in such a way as to lower the secondary peak value, thereby forcing more stored energy to be dissipated in the arc of the contactor. From the above discussion, we have tried to explain that arc losses are inherent to the interruption of this type of circuit. From the fact that the contactor losses are essentially independent of the time of opening, we can infer: (1) that a highly accelerated contactor opening will not reduce the arc losses, and (2) that an inconsistent opening time does not affect the secondary current peak, thereby not changing the performance of the welding machine. The limitations of this latter statement are discussed in detail in a later part of the article.

## Method of Current Interruption by Means of Multiple Pole Contactors

For the past few years, electromagnetic stored energy resistance welding machines have been used extensively with satisfactory operation by means of a multi-pole contactor in each of the supply lines. The contactors now used differ considerably from ordinary d.-c. circuit breakers in the size of arc shields, speed of operation, means of adjustment and arc blowout coils, and are the result of a long period of development.

Three conditions must be fulfilled in any contactor which is to be used for high-speed rupturing of a d.-c. inductive current. The opening speed must be high, the total distance between tips in the open position must be large, and a means of de-ionizing the arc quickly must be provided. A large single pole contactor which would fulfill the above conditions would be entirely impractical. In the first place, due to the arcing and consequent heating of the contact masses the tips must necessarily be of large dimensions. Secondly, since a high opening speed is essential, the inertia forces on the armature will be large, so that a rigid construction of the required strength is difficult to obtain. In the third place, the entire over-voltage appearing across one set of tips would produce such an intense degree of ionization that no simple method of quenching the arc could be readily devised. Lastly, the total traveling distance required so that the final opening be much greater than the distance at which breakdown would occur entails complications.

The conditions mentioned above are satisfactorily fulfilled by means of multi-pole contactors as illustrated schematically in Fig. 4. In this system, a number of contactors are placed in series in each line feeding the reactor, four being the most common for average sized machines. Across each of the contacts *1A*, *2A*, *3A*, *1B*, *2B* and *3B* in Fig. 4 are connected low value resistors. By means of a variable resistance in parallel with the actuating d.-c. coil in each set of contacts, the multi-pole unit may be adjusted so that the contacts open in any sequence desired. Actually, the adjustment is such that the contacts open, respectively, in the following order: *1A* and *1B*, *2A* and *2B*, *3A* and *3B*, *4A* and *4B*. In this manner, only contacts *4A* and *4B* completely break the circuit. Due to the resistance introduced into the circuit by the opening of the first three contactor sets, the current interrupted by the

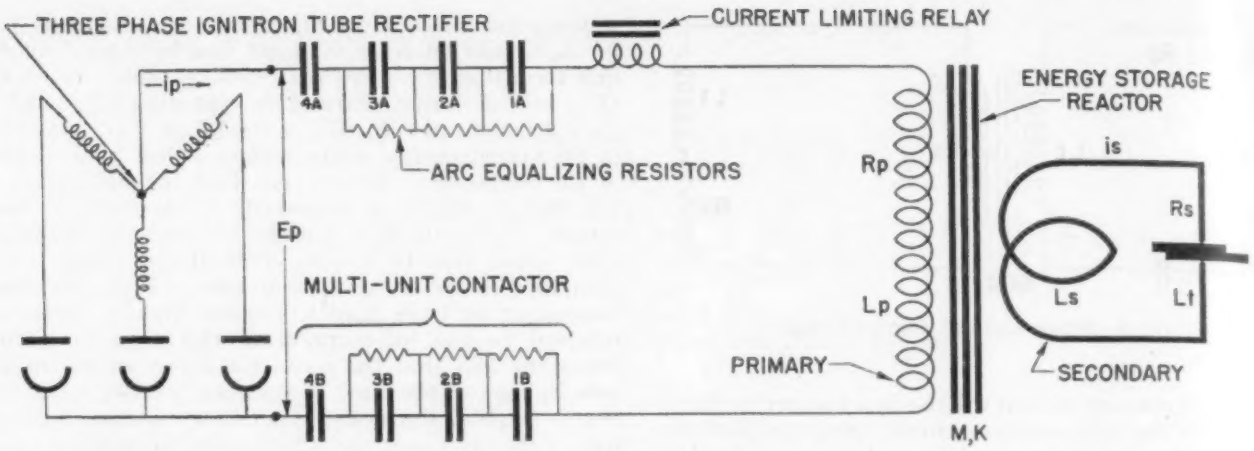


Fig. 4—Schematic Diagram of Existing Common Method of Interrupting the Primary Current of Electromagnetic Resistance Welders

last set of contactors has been greatly reduced so that the amount of arcing occurring across them is not unduly severe. As a matter of fact, the adjustment is made so that the arcing on each of the eight sets of contacts is equal. The ionization produced at each contact is minimized to an easily controlled factor because the overvoltage on each is of the order of magnitude of one-eighth that which would appear across a single pole performing the same function. By the correct design of blowout coils and arc shields, therefore, the arcs are quickly extinguished. As the traveling distance for four poles is four times that of each single unit, the stroke on each unit is held within entirely practical limits, and the speed of opening can easily be made of adequate value. Fig. 6 (A) shows an oscillogram of primary and secondary currents during the operation of an electromagnetic welding machine employing the above contactor arrangement.

There are two factors which prevent this method from being entirely satisfactory: (1) Each contact pole must open at the proper instant during the interrupting sequence in order to insure equal arcing across all contactors. This necessitates maintenance and adjustment of the timing circuits of the contactor coils. (2) The energy which is dissipated in the arcing is lost to the welding system. Since this energy, as shown above, may be as much as 23% of the stored energy, the efficiency of the system is lowered by this amount. Both these limitations of the multi-pole method are due to the arcing across the contactor, which, as we have seen, is inherent to the system.

## Physical Considerations of Shunting a Condenser Across a Contactor

In order to improve the current interrupting system, it has been deemed necessary to develop a device which will open the primary circuit without any arcing. In many similar problems, this has been accomplished by shunting the contact points by a condenser and this method is now employed in such everyday devices as the ignition circuit in automobiles and in telephone networks. It was therefore of interest to investigate the applicability of this method of current interruption to electromagnetic energy storage welders where both current and inductance are relatively high. Suppose we replace the multi-pole contactors in Fig. 4 by a single pole contactor shunted with condensers and investigate the physical phenomena of opening the circuit (see Fig. 5). The initial conditions are that the primary current $i_p$ is flowing through the closed contactor ($S$), $R_p$, $L_p$ and $M$ where it induces the secondary current ($i_s$). During the very short time of opening of the contactor, the current in the condenser ($i_c$) rises to the value $I_p$ and subsequently decays at a rate which is determined

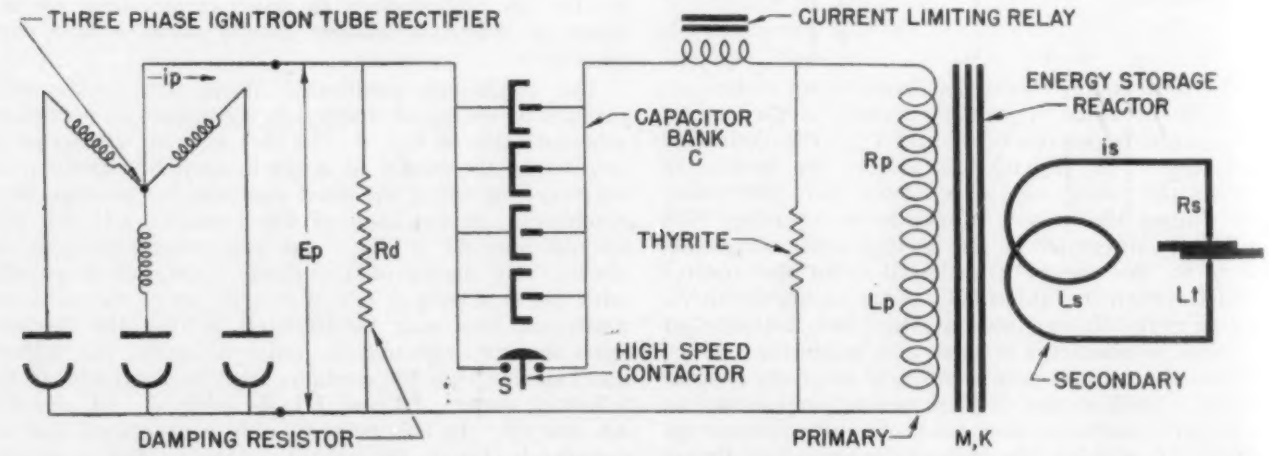


Fig. 5—Schematic Diagram of the New Contactor and Capacitors Connected Into the Primary Circuit of an Electromagnetic Resistance Welder

by the circuit parameters. At any time during the decay, the voltage across the condensers, $e_c = 1/C \int i_c dt$, which is also equal to the overvoltage across the primary terminals of the reactor, disregarding the d.-c. voltage and the resistive drops which are all small compared to $e_c$. A maximum value of $e_c$ will be reached at the instant when $i_p$ has decayed to zero, at which moment the energy stored in the primary winding of the reactor $W_p = {}^1/_2 L_p i_p^2 = 0$ and the capacitors $W_c = {}^1/_2 Ce_c^2$ reaches its maximum value. At this instant, the condenser voltage ($e_c$) will cause the primary current to rise again in the opposite direction until it reaches a maximum negative value. From this time on, the primary current will approach a steady state zero value either by a mode of damped oscillations or by decaying exponentially, depending upon the value of the circuit parameters.

During the initial decay of the primary current (from the time of contactor opening until $i_p = 0$), the energy which was stored in the reactor during the charging time is dissipated into two circuits. Most of it is transferred into the secondary circuit where it establishes a high welding current; the rest of it remains in the primary circuit where it is stored in the condensers. The fraction of the total stored energy which is transferred to the capacitance should be equal to the fraction of the stored energy which was dissipated in the arcing of the multi-pole contactors, since this ratio is solely determined by the circuit parameters of the system and is independent of the amount of the stored energy or of the method employed for current interruption. Whereas the energy dissipated in the arcing is lost to the system, the corresponding capacitatively stored energy is recovered and is transferred to the reactor, and thereby to the secondary circuit during the time that $i_p$ changes from its zero value to its negative peak. Therefore, $i_p$ changes continuously from its maximum charging value to its negative peak value, during which time it induces a voltage across the secondary circuit which is a function of the turn ratio and of the rate of change of the primary current. This voltage is the driving emf. of the secondary current which rises during the period of decay of $i_p$ and attains its maximum value at the instant that $i_p$ reaches its negative peak.

In order to prevent arcing across the contact points of the contactor, the interrupting system must be constructed in such a manner that it will fulfill the following conditions: (1) Since a very high voltage appears across the contact points at the beginning of the contactor opening, the initial acceleration of the movable contact must be high and its speed and stroke must be such that at any instant during the opening operation, the contact points have separated sufficiently to prevent ionization of the surrounding medium. (2) The inductance of the circuit connecting the condenser to the contactor must be low. The first requirement is met by a specially constructed contactor which has been developed and which is described in a later part of this article.

The inductance of the condenser circuit is of paramount importance since it delays the flow of current into the capacitors. It is comprised of the self and mutual inductances of the leads which connect the condensers to the contactor and of the internal inductance of the capacitors. When impressing a d.-c. voltage across a pure capacitance, the current is generally assumed to reach its maximum value instantaneously and then to decay exponentially; i.e., initially the capacitor acts as a zero impedence parameter. Since in any physical circuit there is always some inductance present, the condenser current will not rise instantaneously, but according to the time constant of the circuit. If the inductance of the leads is relatively high, arcing will occur across the contact points at the instant of their separation because the current rise into the condenser will be delayed. It was found experimentally that the effect of the lead inductance could be reduced to a minimum by passing the charging current along the terminals of the capacitors and through the contactor. By this arrangement, which is shown schematically in Fig. 5, it is possible to avoid arcing.

### Circuit Equations When Using Shunt Condensers

The basic circuit equations during the discharge of the reactor are (see Fig. 5):

For the Primary Circuit:

$$-E_p - L_p \frac{di_p}{dt} + M \frac{di_s}{dt} + R_p L_p + e_c = 0 \qquad (5)$$

For the Secondary Circuit:

$$-M \frac{di_p}{dt} + (L_s + L_t) \frac{di_s}{dt} + R_s i_s = 0 \qquad (6)$$

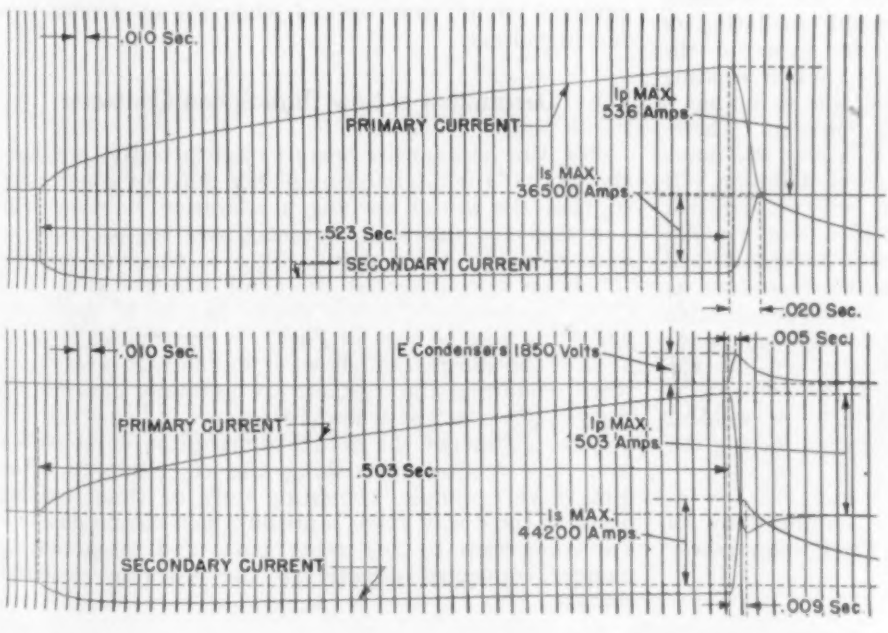


Fig. 6 (*A*)—Oscillogram of Primary and Secondary Currents of a Standard Size Electromagnetic Welder with Primary Current Interrupted by Means of the System Shown in Fig. 4




Fig. 6 (*B*)—Oscillogram of Primary and Secondary Currents of a Standard Size Electromagnetic Welder with Primary Current Interrupted by Means of the System Shown in Fig. 5

These equations are identical with Equations 1 and 2 if $e_c$ is substituted for $e_A$. The equations can be readily solved for the voltage across and for the total energy stored in the capacitance, since the expressions for these values are the same as those in Equations 3 and 4. (For simplification, we make the same assumptions as we did in the previous development.) We can find an approximate value for the secondary peak current ($I_{sm}$) by solving equation 6, from which

$$I_{sm} = \Delta I_p \cdot \frac{n_p}{n_s} \cdot K \left[ 1 - \frac{1}{1 + \frac{L_s}{L_l}} \right] \left[ 1 - \frac{1}{1 + \frac{2(L_s + L_l)}{R_s t_c}} \right] \quad (7)$$

where $\Delta I_p$ is the total change in primary current during the discharge period, $n_p/n_s$ is the turn ratio of the reactor windings, and the other symbols are the same as those in previous equations. The expression for $I_{sm}$ is identical for both methods of current interruption and we see that its value is proportional to $\Delta I_p$, is a function of the circuit constants of the machine, and is fundamentally independent of the time of current interruption. It is to be noted that $I_{sm}$ will be independent of the interrupting time ($t_c$) as long as $R_s t_c$ is much smaller than $(L_s + L_l)$, which is the case in both methods of current interruption. When the multiple contactors are very badly out of adjustment, however, $t_c$ may be a relatively long time so that $R_s t_c$ will be of comparative magnitude with $(L_s + L_l)$. This will have the effect of lowering the magnitude of $I_{sm}$, which is then no longer independent of $t_c$.

In the multiple pole method of current interruption, $\Delta I_p$ is equal to the maximum primary charging current, while in the method of condenser interruption, $\Delta I_p$ is a sum of the charging current and of the negative peak of primary current. Therefore, for any given value of $I_p$, $I_{sm}$ will reach a higher peak when using condensers than it would when interrupting by the original method. Figure 6 shows oscillograms of current variation for both methods of interruption and illustrates readily the physical phenomena which occur while opening the circuits.

The current decay after interruption may be determined by solving the differential Equations 5 and 6 for $i_p$ and $i_s$. During this time, $E_p = 0$ (since the rectifying tubes are extinguished), and $e_s = 1/C \int i dt$. The rate of current decay is determined by three time constants, and the type of decay (either damped oscillating or exponential) can be controlled by the value of the damping resistance ($R_d$) (see Fig. 5). When welding heavy gages of light alloys, it is desirable to obtain a slow exponential decay of welding current. Therefore, $R_d$ should have such a value ($R_{de}$) that the mode of current decay will be one of critical damping. If $R_d$ is smaller than $R_{de}$, the currents will oscillate; if $R_d$ is larger than $R_{de}$, the currents will fall off rapidly to zero. The value of the capacitance ($C$) is determined by both theoretical and practical considerations such as circuit parameters, maximum energy stored, permissible overvoltage, and desired time ($t_c$) for reaching the secondary peak. These conditions are determined by the maximum welding capacity for which the machine is built and by the nature of the metals to be welded. For instance, machines are now in operation having the following characteristics:

Power rating—40 kw., 150 v., d. c.; supplied by an ignitron rectifier from a balanced three-phase power system
Throat depth—36 in.

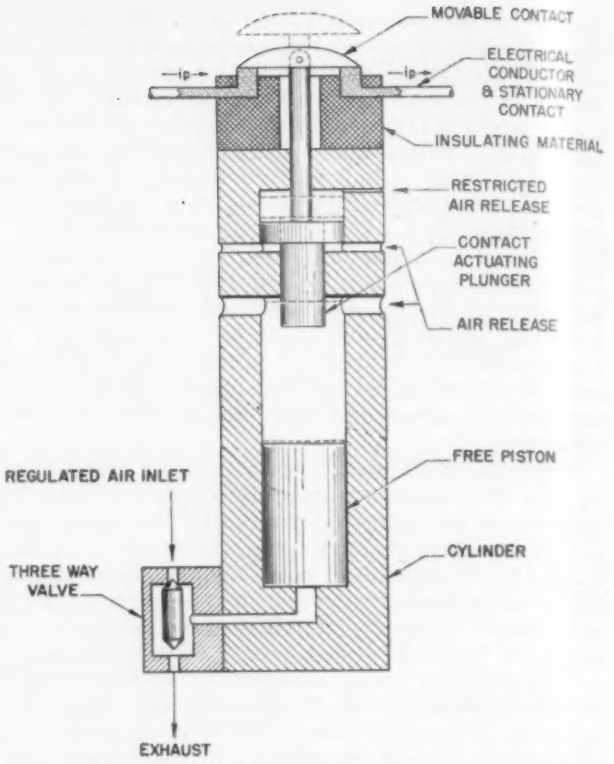


Fig. 7—Schematic Cross Section of the New High-Speed Pneumatic Contactor

Maximum secondary peak current—50,000 amp.
Maximum welding capacity—0.081 + 0.081 Alclad 24ST and other light alloys of the same thickness
Capacitance—480 mfd.
Time ($t_2$) to reach secondary current peak—0.009 sec.
Instantaneous maximum condenser voltage—2000 v.

As an added safety device, a protecting resistor such as a Thyrite may be connected across the primary terminals of the reactor. The resistance of Thyrite varies inversely as a definite exponent of the applied voltage; i.e., at normal voltage these resistors are practically insulators, while at high voltages they become good conductors. In the present application, the Thyrite resistor protects the circuit elements from the dangerously high overvoltage which would occur if the primary circuit were opened while the electrodes were not in contact.

## Description of New High-Speed Contactor

For this system to operate satisfactorily, we have shown that the interrupting device must be constructed so that the initial opening acceleration be very high and that the movable contact travel so fast that no ionization can take place. Since it was not possible to obtain a commercial contactor which would fulfill these requirements, a new device had to be developed which, as may be seen in Fig. 7, is pneumatically operated. The illustration shows it in the rest position, in which condition the contacts are normally closed. No current flows except when the reactor is being charged because all except the actual interruption is controlled from the rectifier furnishing the d.-c. supply. The unit is very simple, consisting only of three moving parts: a three-way valve, a piston which has no mechanical connection to any other part, and an actuating plunger connected directly to the movable electrical contact.

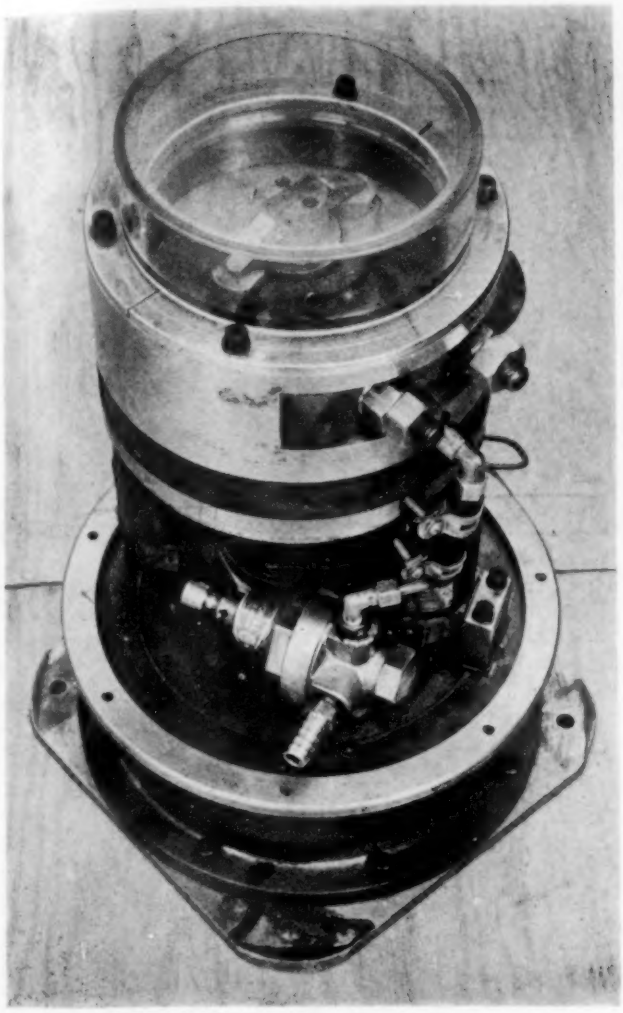

Fig. 8—Photograph of "Dynatrol" Unit—Cover Removed (Patent Pending—Sciaky Bros., Chicago)

When the electric current in the primary of the welding reactor has reached a predetermined value ($I_s$), the current limiting relay (Fig. 5) makes an electrical contact in the external sequence which completes the circuit to the actuating coil of the three-way valve. As soon as this closes (moves to the down position), air pressure from a regulated supply applies a force to the bottom of the free piston which then moves upward in the cylinder. By the time it reaches the bottom of the contact actuating plunger, it has accumulated a large kinetic energy. This energy is transferred to the plunger by impact which causes the movable contact to open at a very high acceleration. The mechanical energy from this point on is absorbed by the compression of the air on the top of the contact actuating plunger which is allowed to exhaust slowly through a restricted air release. This permits bringing the piston and plunger to rest, as indicated by the dotted lines, with a minimum of inertia forces.

For returning the contacts to the rest position, the three-way valve is caused to move to the "Up" position which exhausts the air from the bottom of the free piston, allowing it to drop to the bottom of the cylinder. The plunger and contact then fall to the normally closed position. A system of maintaining pressure on the contacts during the current flow is incorporated in the actual contactor, but is irrelevant to the high-speed interruption operation of the unit and is not shown in the diagram.

Contrary to what we have seen above pertaining to the impracticability of using a single pole contactor, the elimination of the arcing has made it possible to develop one which is entirely satisfactory, since (1) there is no longer any heat effect; (2) the mass and surfaces of the movable contact are determined only by the current to be conducted during the charging period, (3) the movable contact may be made both light and strong by the use of appropriate elastic materials, and (4) the reduced mass requires a relatively small impact force for producing a high acceleration.

A contactor which has been developed along these lines (Fig. 8) and submitted to severe load and life tests has proved capable of interrupting consistently the charging current on an electromagnetic stored energy welding machine over many millions of operations with no appreciable deterioration. The device is now commercially available under the name "DYNATROL."

It is too early to foresee the extent of application of the device; however, its usefulness should ultimately extend much beyond its present scope.

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## Comments on Structural Failures in Welded Ship Construction

(*Continued from page 232*)

an intercostal member for, say, six frame spaces forward and aft of each corner on the underside of the main deck plating by welding inverted angle headers in line with the deckhouse sides. Also, the main deck plating could have doubler plates or heavier inserts installed in way of the house corners. I would also like to suggest that house corners should have a much larger radius, say 2 ft instead of the conventional 6-in. or 8-in. radius corners.

A third suggestion is to require that the sheer strake plating be of thicker material for a distance of, say, six frame spaces fore and aft of all four corners of the house. Other means of providing continuity at the corners of the deckhouse will no doubt occur to the committee, but it is the writer's considered opinion that our shipbuilding rules should immediately be revised to include some provision for elimination of the existing discontinuity in al cases where the main deckhouse is a welded integral box girder superimposed on the midship $^1/_2$ length of the hull.

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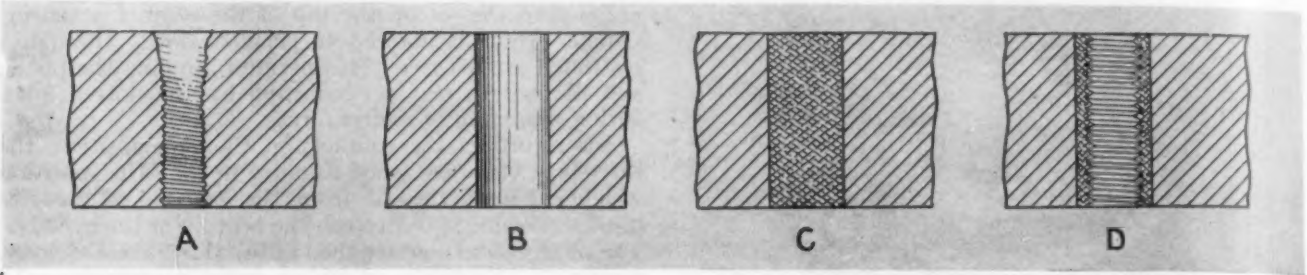
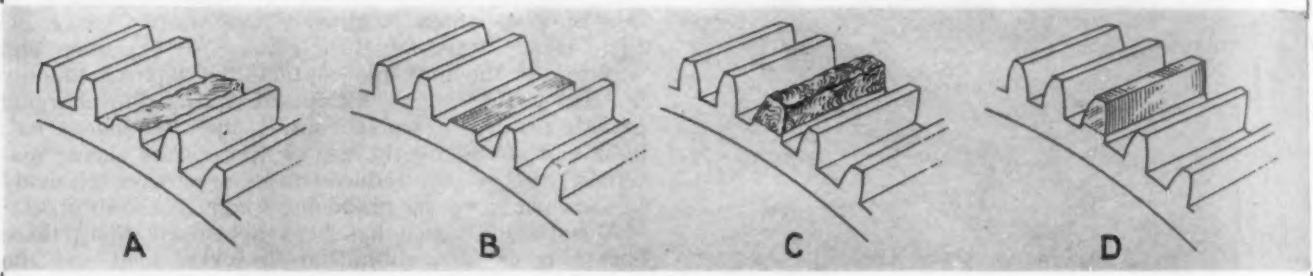
# Wartime Plant Maintenance

By G. C. Becker*



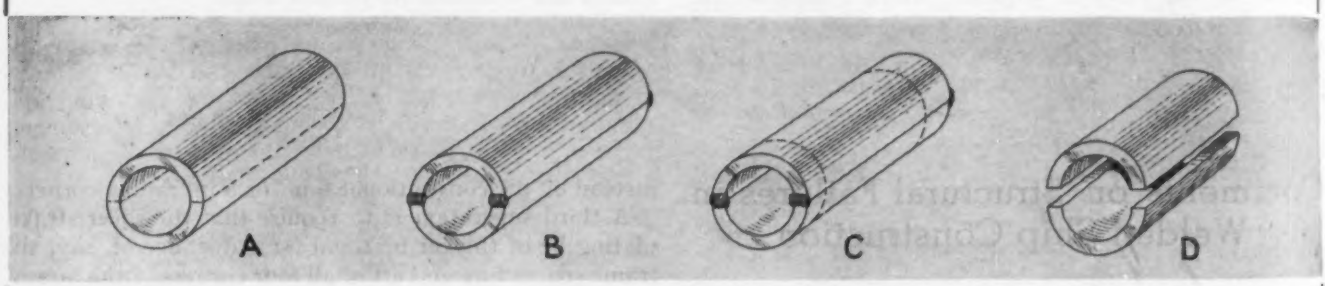

## Stripped Holes

When threaded holes wear oversize, they can be quickly repaired by following the procedure shown in the sketches. The worn hole (*A*) is bored out to give a clean surface (*B*) for the bronze-welding operation. After completely filling the hole with layers of bronze-weld metal (*C*) it is bored, reamed and finally tapped (*D*).




## Broken Gear Teeth

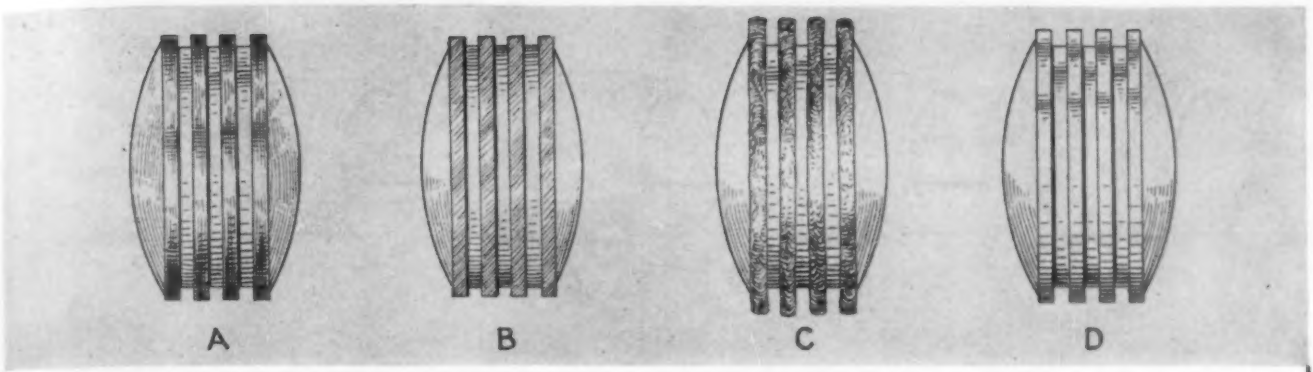
The repair of broken gear teeth is a common type of maintenance job. As shown, the break (*A*) should be cleaned (*B*) before building up a new tooth with bronze welding rod (*C*). The new tooth should be made only slightly oversize so that very little metal will have to be removed in the final machining (*D*).




## Bronze Bushings

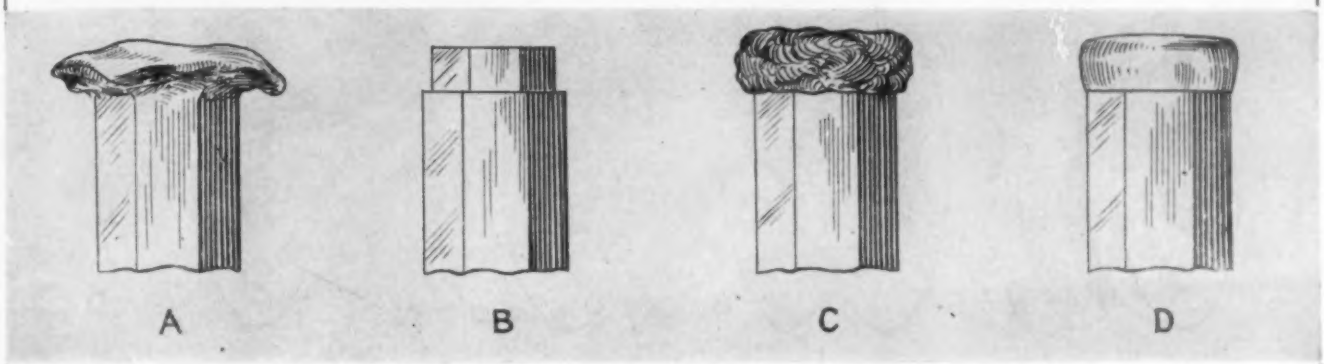
Perfect split shell bushings can be made even though the halves of a split cylinder, when planed and reassembled, no longer form an exactly circular cylinder. The procedure is based on cutting the bronze cylinder into halves (*A*) and holding the halves together by tack welds made by bronze welding (*B*) so that they may be re-turned and re-bored to a true circle (*C*). The welded ends are cut off square (*D*).

* The Linde Air Products Company, New York, N. Y.



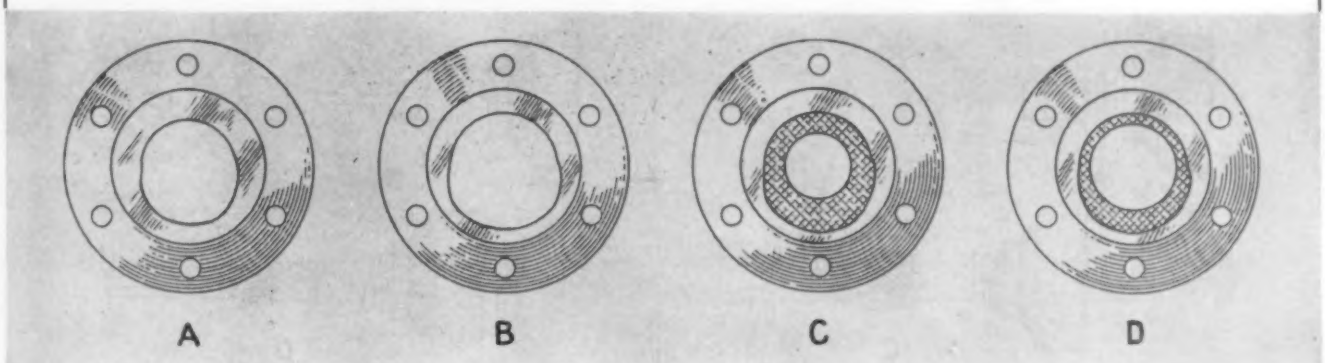

## Worn Pistons

Pistons for compressors, pumps, gasoline and diesel engines, and for various other uses can be reclaimed by bronze surfacing. The worn rings (*A*) are ground undersize (*B*) for the bronze deposit (*C*). Finally the rings are machined to size (*D*). Cast-iron welding rod should be used for high-temperature service, or where the bronze-weld metal might be subject to corrosion.



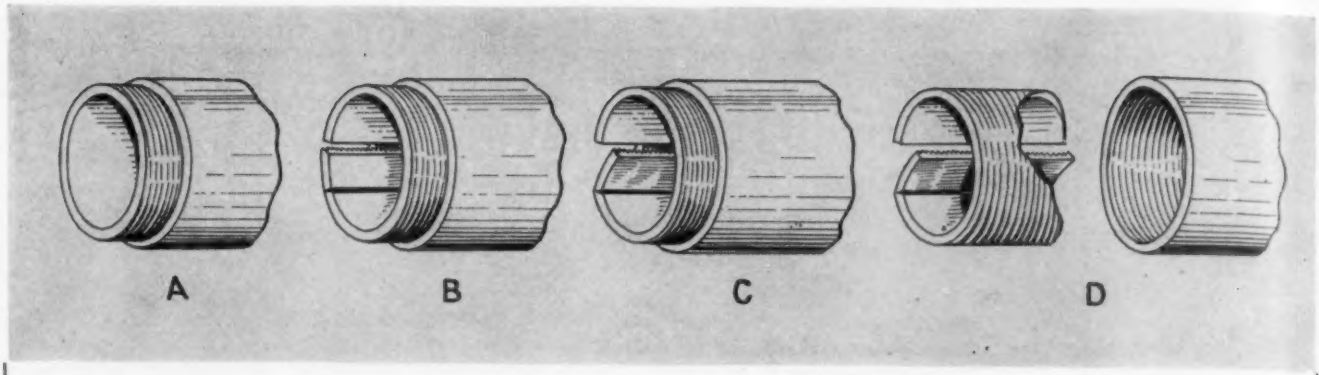

## Upset Chisels

Chisels, drills, wedges and other hammer-struck tools that have become unfit for further use through spalling and cracking (*A*) can be salvaged by "safe-ending." After the damaged metal has been cut away, a $^1/_8$-in. shoulder $^1/_{16}$ in. deep is ground around the striking end (*B*). A $^1/_8$-in. collar of bronze-weld metal is then deposited (*C*) and the ends are ground square (*D*).



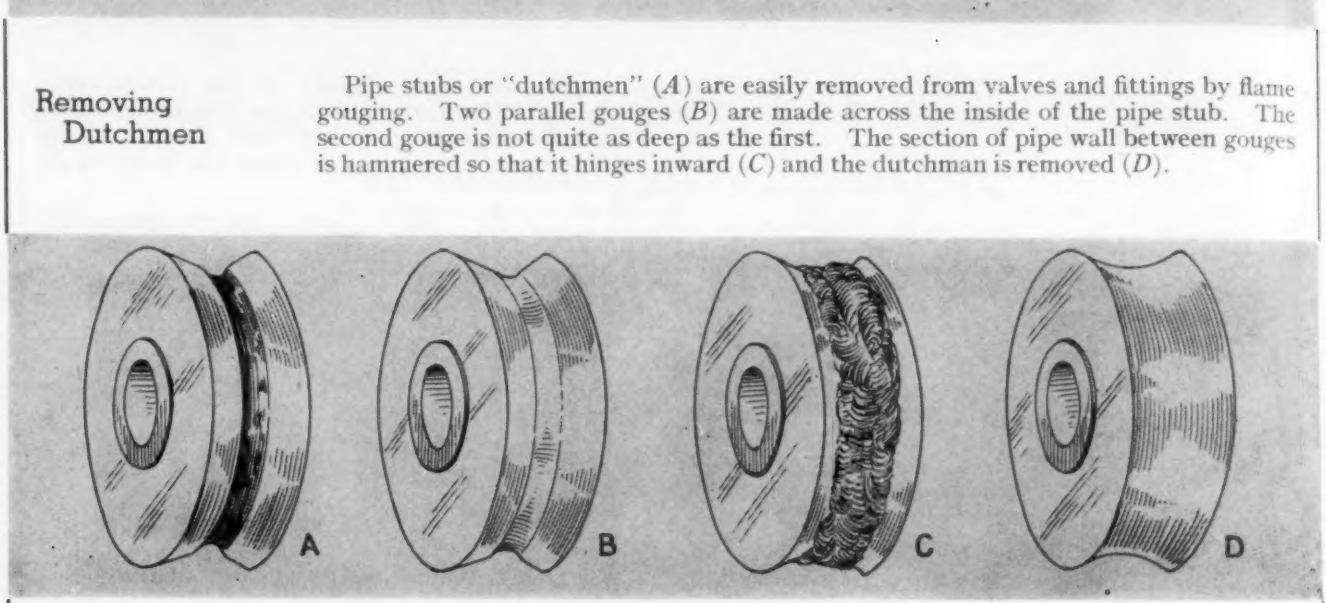

## Worn Hubs

Hubs with badly worn inner surfaces can be saved from the scrap pile through the use of bronze surfacing. In addition, the piece of equipment of which the hub is a part will be restored to efficient operation. The sketches show how the worn surface (*A*) is cleaned (*B*), then bronze surfaced oversize (*C*), and finally re-bored (*D*).



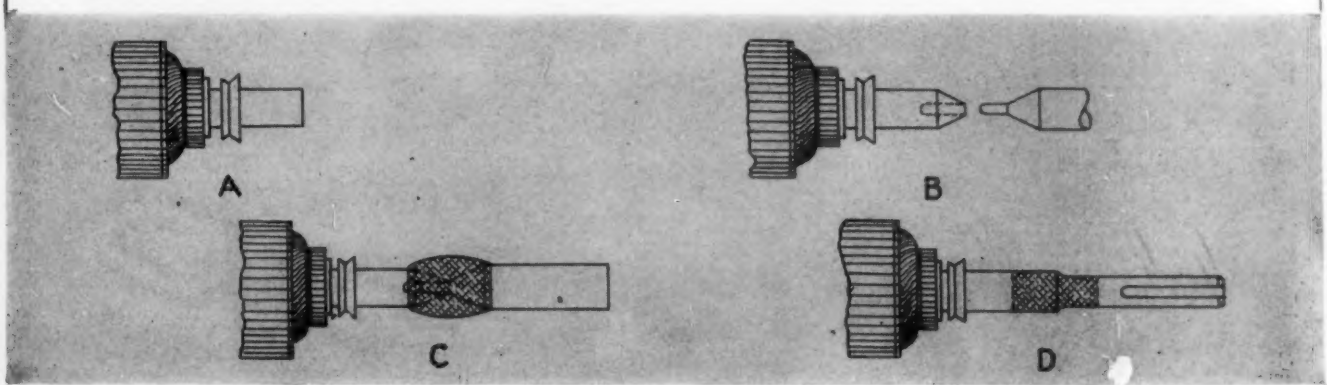

**Removing Dutchmen**

Pipe stubs or "dutchmen" (*A*) are easily removed from valves and fittings by flame gouging. Two parallel gouges (*B*) are made across the inside of the pipe stub. The second gouge is not quite as deep as the first. The section of pipe wall between gouges is hammered so that it hinges inward (*C*) and the dutchman is removed (*D*).




**Grooved Sheaves**

Spools and sheave wheels that become worn and deeply grooved (*A*) can be restored by bronze surfacing. The bronze will wear longer than the casting itself and with less wear on the cable. Sketched are the stages of the procedure, which includes preparing the surface (*B*), making the deposit (*C*) and the final grinding (*D*).




**Lengthening Shafts**

Electric motor shafts (*A*) can be extended without removing them from the armatures. The procedure includes tapering and drilling the shaft to take a small pilot (*B*), bronze welding (*C*) and finishing (*D*). Any stresses that may exist can be released by taking a roughing cut over the joint, recentering and refinishing

# *Tentative Specifications for*

# ALUMINUM AND ALUMINUM-ALLOY METAL ARC-WELDING ELECTRODES[1]

**Serial Designation: B 184 - 43 T**

ISSUED, 1943.[2]

This is a Tentative Standard and under the Regulations of the Cooperating Societies is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the A.S.T.M., 260 S. Broad St., Philadelphia 2, Pa., or of the A.W.S., 33 W. 39th St., New York 18, N. Y.

*These Specifications were prepared jointly by the American Welding Society and the American Society for Testing Materials.*



## Scope

1. These specifications cover coated or covered metal arc-welding electrodes for welding aluminum and aluminum alloys. The coating or covering is referred to in these specifications as covering.

## Manufacture

2. The electrodes may be made by any methods that will yield a product conforming to the requirements of these specifications.

## Standard Sizes and Lengths

3. Standard sizes and lengths of electrodes are as shown in the following table. In all cases, standard size refers to the diameter of the core wire.

| Electrode Classification Number | Standard Sizes, Diameter of Core Wire, in. | Standard Lengths, in. |
|---|---|---|
| Al-2 and Al-43 | 5/32, 1/8, 3/32, 5/16, 1/2, 5/16, 1/4 | 14<br>18 |

[1] Under the standardization procedure of the two Societies, these specifications are under the jurisdiction of the A.W.S.-A.S.T.M. Joint Committee on Filler Metal.

[2] Accepted by the A.S.T.M. at annual meeting, June, 1943; approved by A.W.S. Board of Directors, June 10, 1943.

## Chemical Composition

4. (*a*) The electrode core wire for Al-2 electrodes shall conform to the requirements as to chemical composition prescribed for grade 99.0 in the Tentative Specifications for Aluminum Ingots for Remelting (A.S.T.M. Designation: B 24) of the American Society for Testing Materials[3] which are shown in Table I.

TABLE I.—CHEMICAL REQUIREMENTS.

NOTE.—Analysis shall be made only for the elements specifically mentioned in this table. If, however, the presence of other elements is indicated in the course of routine analysis, further analysis shall be made to determine that the total of these other elements is not present in excess of the limits specified for "total other impurities" in the last item in the table.

| | Electrode Classification | |
|---|---|---|
| | Al-2 | Al-43 |
| Copper, max., per cent | 0.2 | 0.4 |
| Iron, max., per cent | 0.6 | 0.8 |
| Silicon, per cent | 0.5 max. | 4.5 to 6.0 |
| Magnesium, max., per cent | 0.05 | 0.05 |
| Manganese, max., per cent | 0.05 | 0.3 |
| Zinc, max., per cent | 0.05 | 0.2 |
| Titanium, max., per cent | 0.03 | 0.2 |
| Nickel, max., per cent | 0.03 | |
| Aluminum, per cent | 99.0 min. | remainder |
| Total other impurities, per cent | 0.1[a] | 0.3 |

[a] None of the elements included in "total other impurities" shall exceed 0.03 per cent maximum.

[3] 1942 Book of A.S.T.M. Standards, Part I, p. 1115.

(*b*) The electrode core wire for Al-43 electrodes shall conform to the requirements as to chemical composition for alloy S2 as prescribed in the Tentative Specifications for Aluminum-Base Alloy Sand Castings (A.S.T.M. Designation: B 26) of the American Society for Testing Materials[4] which are shown in Table I.

## Weld Tests

5. (*a*) To determine the suitability of the electrodes for producing welds of adequate strength, ductility, and soundness, tension and bend tests shall be conducted as prescribed in the following Sections 6 to 8.

(*b*) For electrodes 5/32 in. and smaller, the performance of these sizes shall be judged by the performance of 5/32-in. electrodes of the same classification. For electrodes 5/16 in. and larger the performance shall be judged by the performance of 1/4-in. electrodes of the same classification.

## Preparations of Test Specimens

6. (*a*) A test plate shall be prepared as shown in Fig. 1, using the size of electrode prescribed in Section 5 (*b*). The material for the test plate shall conform to the following specifications of the American Society for Testing Materials:

(*1*) *For Testing Electrodes of Classification No. Al-2.*—Tentative Specifications for Aluminum Sheet and Plate (A.S.T.M: Designation: B 25).[5]

(2) *For Testing Electrodes of Classification No. Al-43.*—Tentative Specifications for Aluminum-Manganese Alloy Sheet and Plate for Use in Welded Pressure Vessels (A.S.T.M. Designation: B 126).[6]

(*b*) The plate shall be preheated before welding to between 350 and 400 F. All welding shall be done from one side in the flat position. No stress relieving or other thermal treatment shall be done after welding. Test plates shall preferably be so supported that warping due to welding will not cause the finished test plate to be out of line by more than 5 deg. If test plates become warped more than 5 deg., they shall be straightened cold.

(*c*) Two reduced-section tension specimens, one guided-face-bend specimen,

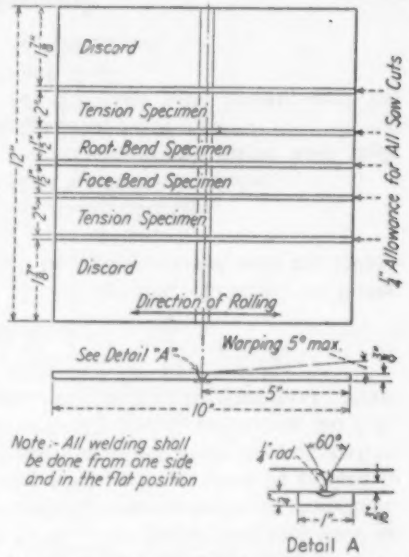



FIG. 1.—Requirements for Preparation of Test Plate for Face- and Root-Bend Specimens.

and one guided-root-bend specimen shall be machined from the finished test plate as shown in Fig. 2. These specimens are in accordance with specimens H-1, E-1, and F-1, respectively, of the A.W.S. Standard Methods for Mechanical Testing of Welds.[7]

## Tension and Bend Test Procedures

7. (*a*) *Reduced-Section Tension Specimens.*—Before testing, the least width and corresponding thickness of the reduced section of the test specimen

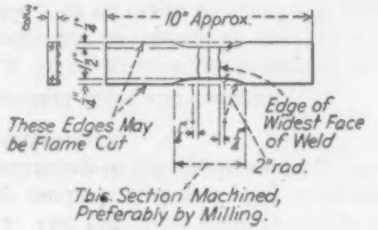
[4] 1943 Supplement to Book of A.S.T.M. Standards, Part I, p. 227.

[5] *Ibid.*, p. 237.

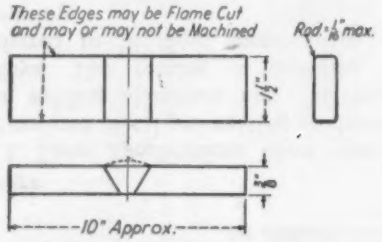
[6] *Ibid.*, p. 251.

[7] 1942 Welding Handbook, p. 1121, Am. Welding Society.

shall be measured in inches. The cross-sectional area shall be obtained by multiplying the width by the thickness. The specimen shall be ruptured by a tension load and the maximum load in pounds determined. The tensile strength in pounds per square inch shall be calculated by dividing the maximum load by the cross-sectional area.




(*a*) Tension Specimen.




(*b*) Face-and-Root-Bend Specimens.

FIG. 2.—Details of Test Specimens.

NOTE.—Weld reinforcement shall be removed flush with the base metal; undercut shall not be removed. All machining shall be done transverse to the weld.
Tension corners of bend specimens shall be broken slightly with a file.
All specimens shall be plainly marked on both ends.

(*b*) *Guided-Root- and Face-Bend Specimens.*—Each specimen shall be bent in a jig having the working contour shown in Fig. 3, and otherwise substantially in accordance with that figure. Any convenient means may be used for moving the plunger member with relation to the die member. The specimen shall be placed on the die member of the jig with the weld at mid-span. Face-bend specimens shall be placed with the face of the weld directed toward the gap, and root-bend specimens shall be placed with the root of the weld directed toward the gap. The two members of the jig shall be forced together until the specimen conforms to a U-shape, and until a wire $\frac{1}{32}$ in. in diameter cannot be placed between the specimen at any point on the curvature of the plunger member of the jig. The specimen shall then be removed from the jig.

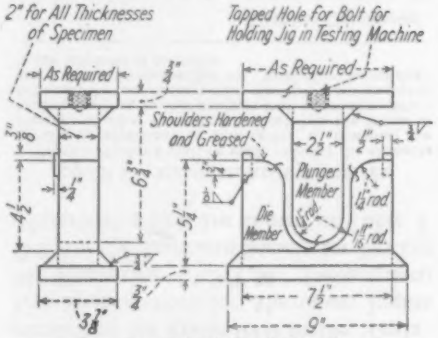



FIG. 3.—Guided-Bend-Test Jig.
Hardened rolls may be used on shoulders if desired. Specific dimensions for ¾-in. specimen.

**Test Results Required**

8. (*a*) *Reduced-Section Tension Tests.*—For electrodes of classification No. Al-2, the tensile strength of each specimen tested shall be not less than 12,000 psi. For electrodes of classification No. Al-43, the tensile strength of each specimen shall be not less than 14,000 psi.

(*b*) *Guided Root- and Face-Bend Tests.*—The convex surface of the bend test specimens shall be examined for the appearance of cracks or other open defects. Any specimen in which a crack or other open defect is present after bending, exceeding $\frac{1}{8}$ in. measured in any direction, shall be considered as having failed. Cracks occurring on the corners of the specimen during testing shall not be considered.

**Permissible Variations in Dimensions**

9. (*a*) Electrodes shall be bare or free from covering for a distance of about 1 in. but not more than $1\frac{1}{4}$ in., for making contact with the holder.

(*b*) The arc end of each electrode shall either be bare or the coating easily removable with the fingers to permit easy striking of the arc. The length of any bare portion of the arc end, measured from the end to the point where the full cross-section of the coating obtains, shall not exceed one core-wire diameter or in any case $\frac{1}{8}$ in.

(*c*) The diameter of the core wire shall not vary more than plus or minus 0.002 in. from the standard size specified. The length shall not vary more than plus or minus $\frac{1}{8}$ in. from that specified.

**Electrode Coverings**

10. (*a*) Electrodes shall be suitable for making butt and fillet welds in the flat position and for making butt welds in the vertical position.

(*b*) The coverings shall have sufficient electrical resistance at or below 100 F. to insulate effectively against a difference of potential of 100 v.

(*c*) The coverings shall during welding be consumed uniformly on all sides and shall not blister or burn back from the core wire.

(*d*) The slag produced shall be readily removable.

(*e*) The fumes given off from the covering when used in well-ventilated places shall not be injurious to the health of the welding operator.

(*f*) The coverings shall not blister when heated to 400 F.

**Workmanship**

11. (*a*) The core of electrodes shall be of uniform quality and free from injurious segregation, oxides, pipe, seams, or other irregularities.

(*b*) The coverings on electrodes shall be such that they are not readily damaged by ordinary handling and shall be of commercially uniform thickness and shall present a workmanlike appearance. Coverings shall be free from injurious scabs, blisters, abnormal pockmarks, bruises, or other surface defects.

**Packing**

12. (*a*) Electrodes shall be suitably wrapped, packed, boxed, or crated to insure against mechanical damage during shipment or storage. The method of packaging shall be such as to protect the flux coating from absorbing moisture. All packages shall be dated at the time of packing.

(*b*) Standard packages shall be 1 lb. or 10 lb. One-pound packages shall be packed in moisture-resistant wrappings. Ten-pound packages shall be packed in moisture-resistant wrappings, or shall be hermetically sealed, containing ten 1-lb. packages in moisture-resistant wrappings.

**Marking**

13. All bundles, packages, or boxes, shall be legibly marked with the following information:

(*a*) Name of article,
(*b*) Classification number,
(*c*) Manufacturer's name and trade designation,
(*d*) Standard size, length, and net weight, and
(*e*) Guarantee.

**Guarantee**

14. The manufacturer shall make tests at frequent intervals in accordance with the methods prescribed in these specifications, and shall guarantee that the electrodes in all sizes and classes conform to these specifications and each container shall be so marked. The manufacturer's responsibility shall be limited to replacement of any electrodes which do not conform to the requirements of these specifications.

# *THERE ARE STILL*

# *UNDISCOVERED CONTINENTS*

COLUMBUS had a definite goal—a westbound sea route to Asia. But what he found was a new continent—a new source of Nature's wealth.

Modern research also has its goals: it, too, is discovering new resources. Starting from the knowns of science, it charts its voyages into the unknown. Behind each voyage is a theory that there is a passageway.

But research doesn't hold stubbornly to its theories. If it finds islands instead of a continent, it accepts them, for it expects the unexpected. It studies their relation to the known lands of science. And on the basis of its increased knowledge, it makes revised plans for progress. In science there is always a continent ahead.

Just what research will disclose can never be forecast. But history has proved that from research flow discoveries of value to mankind. From Bell Telephone Laboratories there has poured a full stream of improvements in the telephone art.

Bell Telephone Laboratories has kept America leading the world in telephony. And its researches have contributed importantly to other arts of communication—to the phonograph and sound-motion pictures, to radio broadcasting and television.

Today, as ever since Pearl Harbor, its efforts in research and design are devoted to the war needs of the nation.

When peace comes, its organized teams of research scientists and engineers will continue to explore and invent and perfect for the improvement of telephony.

BELL TELEPHONE SYSTEM

# All-Welded Engine Stands

By A. F. Davis*

IN KEEPING with the tremendous growth in the number and variety of airplanes and airplane products now being produced for the industry by means of the electric arc-welding process, the engine stands constructed by the Clayborne Manufacturing Company of Chicago, Ill., stand out as a notable example of ingenuity and engineering skill.

According to officials of the company the structures differ radically in design in that they are built primarily of tubing instead of the usual heavy angles and channels. (See three typical types of stands in Figs. 1, 2 and 3).

In addition to the added strength and economy of the welded type of stand, this form of construction permits designing so that the structure can be folded into a compact, flat position for shipping or storing, taking up only about one-fifth its original space, a vital feature in these days when space is so limited.

The simplicity of construction which is evident in the accompanying photographs was made possible by using carbon steel tubing, cold formed, cut and bent to specifications, then arc welded at the joints to form rigid, portable units that are used for both engine overhaul and assembly operations.

The revolving mounting rings consist of $^1/_2$-in. hot-rolled mild steel plate, including gussets. These cut and shaped pieces are fused into one integral assembly by butt welding at the seam.

A $^5/_{16}$-in. mild steel shielded-arc electrode is used throughout with one pass with a machine current setting of approximately 175 amp. The company utilizes its own stands as positioners to obtain the highest quality of welding efficiency and to speed up the work. Only about $3^1/_2$ hr. time is required to weld-construct a complete unit, according to the reports.

* Vice-President, The Lincoln Electric Co., Cleveland, Ohio.

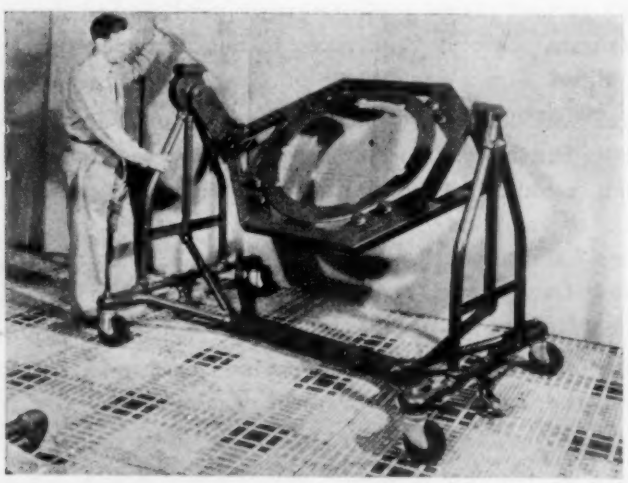
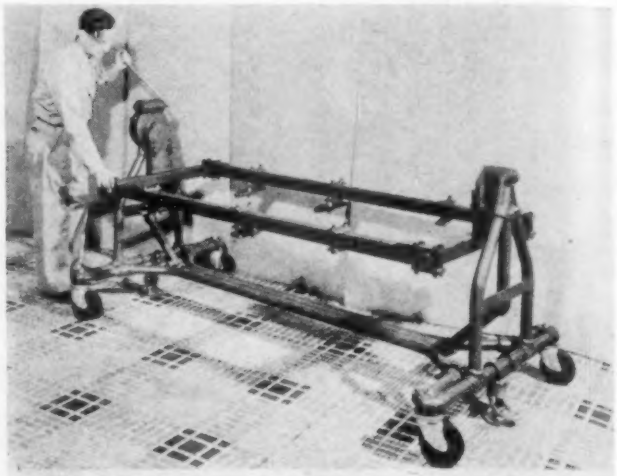


Fig. 1—Portable Stand Used for Radial Airplane Engines, Constructed by Means of Arc-Welding Methods

Fig. 2—"In-Line" Type of Arco-Welded Aircraft Engine Stand



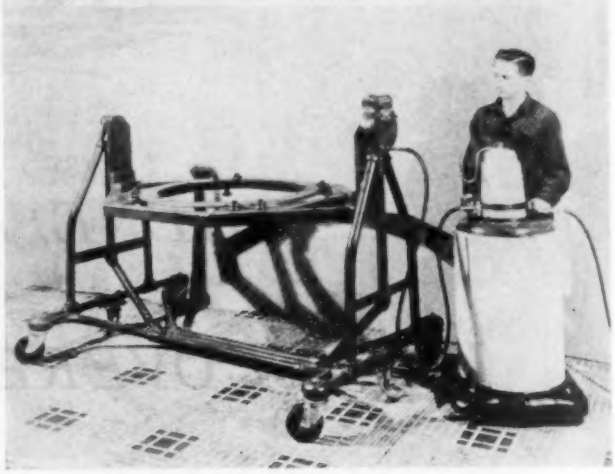
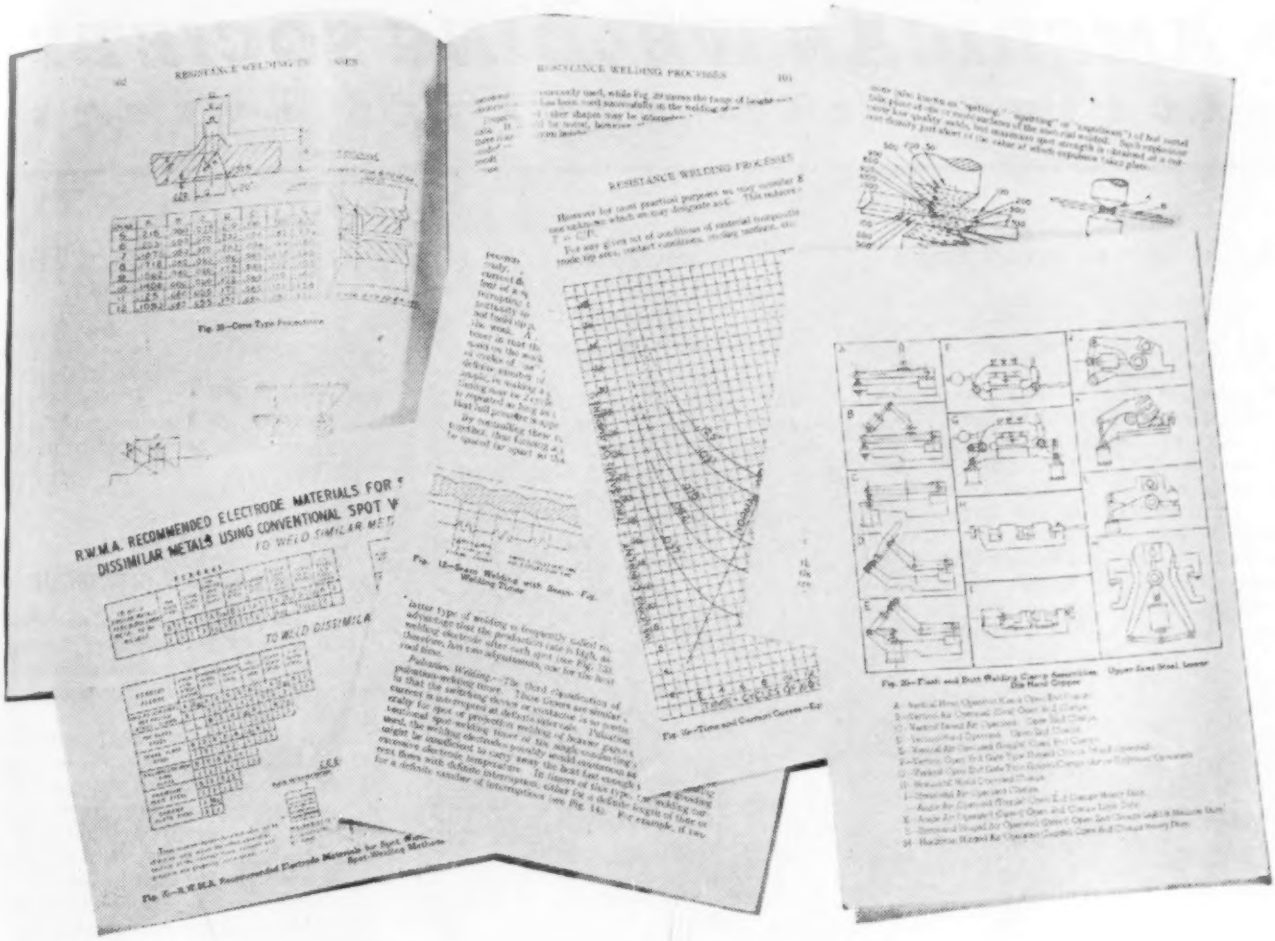


Fig. 3—Arc-Welded Engine Stand Being Force-Packed with Special Lubricant, Thus Sealing Gears against Foreign Matter.

Due to the flexibility of welded design, the stands are built so that the mechanic can revolve the engine in the mounting ring, thus permitting the engine to be turned horizontally, rotated vertically and locked in any desired position. Figure 1 shows one type stand tilted at an angle of approximately 360°. Similar tilting arrangement is included in the "in-line" engine stand shown in Fig. 2.

Another valuable feature made more feasible by modern arc-welded construction is the method of permanent gear-box lubrication shown in Fig. 3. The worm and worm-gear are here shown being force-packed with lubricant-positive protection against dust and sand such as that encountered while the units are in operation on our far-flung battlefronts.

The wide use of these types of welded stands is further testimony of the vital contribution being made by arc welding in the production of items essential to war use as well as peacetime production.



# FACTS and FIGURES

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# THE AMERICAN WELDING SOCIETY

## ACTIVITIES — RELATED EVENTS

### ANNUAL MEETING HEADQUARTERS

Cleveland Hotel, Cleveland, Ohio, is the official headquarters of the AMERICAN WELDING SOCIETY during its 1944 Annual Meeting, October 16th to 19th. Members are urged to mail reservations to Housing Bureau, Cleveland Convention, and Visitors' Bureau, Inc., 1604 Terminal Tower, Cleveland, Ohio, at the earliest possible date. *Room assignments will be made* by Housing Bureau (on which A.W.S. will have representation) *on September 1st.* Preference will be given members in order of receipt. In writing for reservation, be sure to state *you are coming to attend A.W.S. Meeting* so as to insure your being located in Headquarters Hotel. Members who make early reservations will not be disappointed. Six hundred guest rooms are allotted to A.W.S. After these are sold out, the Housing Bureau will endeavor to locate A.W.S. members in hotels as close to Headquarters as is possible. Be wise and send in your reservation now.

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### OUR MARCH COVER PICTURE

The photograph shows the Fort Mifflin Terminal of the Atlantic Refining Co. It is particularly appropriate for the cover of THE WELDING JOURNAL because it shows an all-welded tanker tied up to a welded steel dock, with a welded steel frame building in the background. Oil from the ship is being pumped through welded steel pipe lines to welded steel storage tanks.

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### JANUARY 1939 JOURNALS WANTED

The AMERICAN WELDING SOCIETY has received important requests from libraries for the January 1939 issue of THE WELDING JOURNAL, which is out of stock. Any member having a copy that he does not need would be conferring a favor upon the SOCIETY by sending it to the Society Headquarters.

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### FORTUNE WRITES UP LINCOLN

A very interesting and attractive write-up about Mr. Lincoln and his ideas on incentive pay for industrial workers is described in an interesting article in the February issue of *Fortune* magazine.

### REVIEW OF THE PRACTICAL DESIGN OF WELDED STEEL STRUCTURES

By H. M. Priest

In the present period of tremendous expansion in the industrial use of welding, the publication of this book is timely. Within its 150 pages are set forth the essentials of welding and welded construction with a conciseness that brings much practical information into readily useful form. Engineers and fabricators will find this book a valuable aid in the preparation and execution of welded designs.

Effective designing requires a knowledge of the fabricating tools and methods. Here are to be found brief, yet adequate, discussions of the various welding processes, specifications for electrodes, types of welds, welding positions, qualification tests and inspection. The important subject of weld geometry and stress concentration is treated at some length. Temperature effects, both physical and metallurgical, have received extended attention.

One section deals with the codes of the AMERICAN WELDING SOCIETY. Unit stresses from these codes have been widely adopted for most designing in welded construction and form the basis for the numerous charts and tables throughout the book.

The general and detail design considerations for simple welded joints and connections precede their application to typical structural members. Beam connections are fully treated and considered in the light of continuous structures. A brief section deals with rigid frames.

One of the most useful features of the book are the numerous charts to facilitate the design of welded joints and structural members. These charts are so arranged as to be applicable for any specified unit working stresses.

The growing importance of fatigue in many types of structures is recognized by the inclusion of a section dealing with this topic.

Appended to the book is a short bibliography of literature relating to welded construction, which will be of assistance to those desirous of studying further into the subject.

The book is a practical, working manual that will provide the answers to many questions. In it, the author brings to the reader, the results of his own study and experience in the field of welded construction.

The book is published by the AMERICAN WELDING SOCIETY, 33 West 39th Street, New York 18, N. Y. It is bound in attractive cloth covers and sells for $1.00 per copy.

### ADVISORY STANDARDS FOR WELDING OCCUPATIONS

A revised pamphlet, No. 6, on the above subject, which is part of a series on "Which Jobs for Young Workers?" has been issued by the U. S. Dept. of Labor, Children's Bureau, Washington 25, D. C. Sixty thousand copies of the first pamphlet were distributed.

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### SPOT-WELDING ELECTRODES

The War Production Board on February 7th announced revocation of Limitation Order L-318, which had set standards for the manufacture of all spot-welding electrodes.

Upon investigation it was found that the standards prescribed under the order were not readily adaptable to the types of resistance-welding equipment used in most aircraft construction. Manufacturers of electrodes are now free to produce any types required by their purchasers but will continue to function under the applicable CMP regulations covering their industry.

---

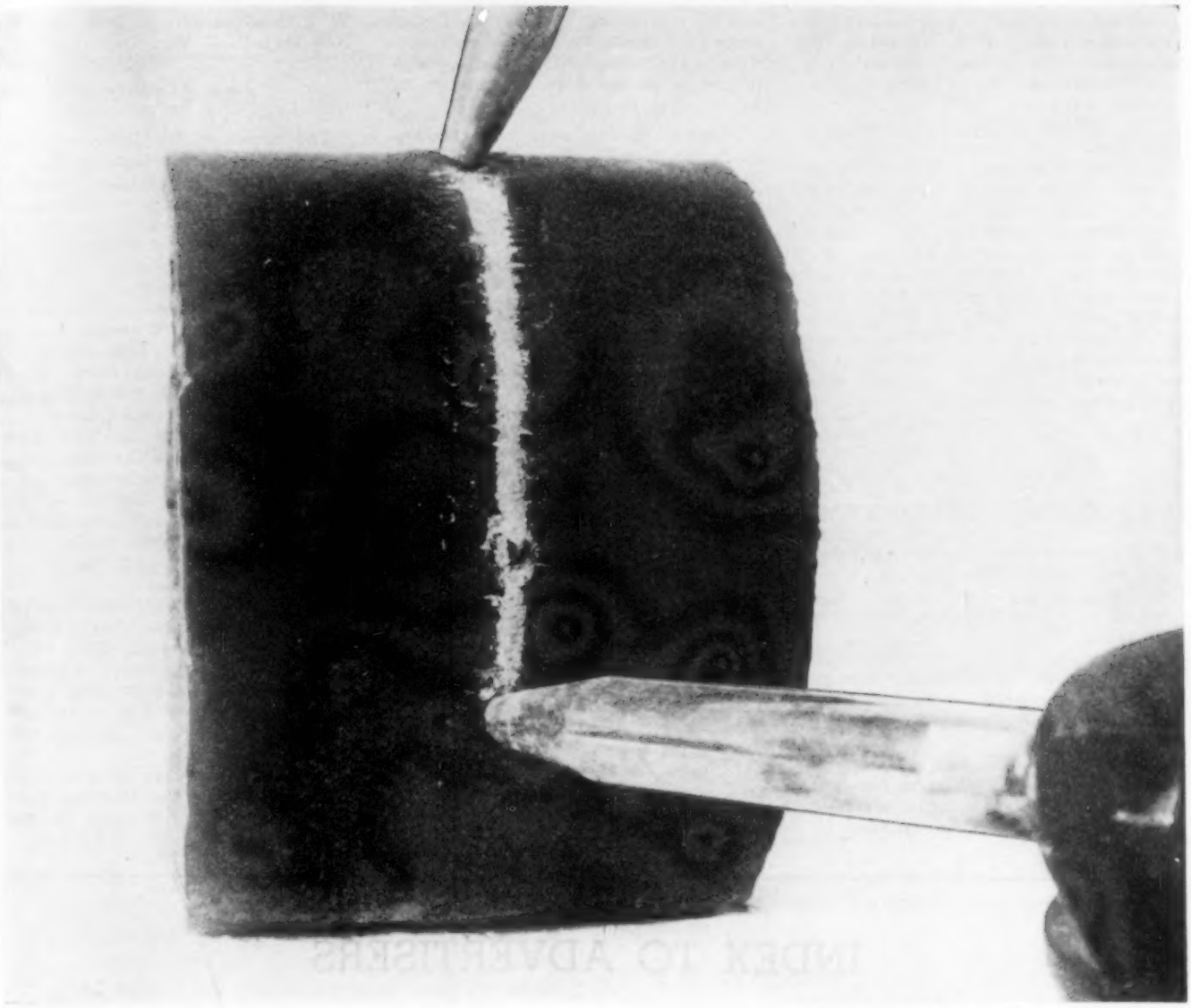
### THE WELDING ENCYCLOPEDIA

*The Welding Encyclopedia*, 11th edition. Edited by L. B. Mackenzie and others, re-edited by T. B. Jefferson. Published by The Welding Engineer Publishing Company, Chicago, 1943. Simulated leather, 6 x 9 in., 976 pp. Price $6.00

The 11th edition should prove to be the most valuable one of all, for *The Welding Encyclopedia* has kept pace with the gigantic strides made by welding during the past two years. The information regarding metallurgy, electricity and the various welding processes has been greatly expanded as have been the discussions dealing with the various welding applications such as shipbuilding and aircraft work.

It was the aim of the editor to present a thorough, detailed treatment of every subject which relates in any way to welding, and in the process of accomplishing this objective it was found necessary to increase the size of the book by 260 pages over the previous edition. These 260 pages represent all new material.

Not only has the information presented been extensively enlarged, but the contents have been rewritten and rearranged, too. As in a dictionary, the subjects are arranged alphabetically. Editorial cross references will be found frequently to facilitate the thorough covering of a subject,



*Magnaflux indication of lack of complete penetration of weld in pressure piping*

## *Welding Freed from the RISKS of . . the* "FAILURE TEST"

**Rapid non-destructive inspection techniques are the subject of continuous research by Magnaflux engineers. The basic magnetic method has, during the war, been extended by the new Magnaglo or fluorescent technique, while Zyglo is a new non-magnetic method applicable to aluminum, magnesium and non-metallics.**

● Putting a welded part, pipe, vessel, or assembly into actual service to see if it will fail is poor practice even when it is necessary. Magnaflux* Inspection fortunately puts this "failure test" generally out of the question.

By means of portable equipment for rapid, inexpensive inspection, *every weld* can be examined non-destructively. Magnaflux Inspection gives positive indications of dangerous (1) surface cracks in welds or parent metal; (2) lack of fusion and incomplete penetration; (3) slag inclusions.

Write for a complete explanation of the advantages in aircraft, piping, pressure vessel, and structural welding. Special applications of Magnaflux techniques and equipment are in daily use for each type of work.

** Magnaflux—the Trade Mark of the Magnaflux Corporation applied to its equipment, materials and methods for magnetic particle inspection.*

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and there is, furthermore, a complete general index, a new feature included for the first time in this edition. This index will undoubtedly add greatly to the convenience of reference.

The 976-page volume is, in reality, in five parts. The first part, a concise encyclopedia of welding, is followed by an appendix which presents many interesting tables, charts, specifications, temperature conversion tables, examples of good and bad welding and an elaborate comparison chart of various welding electrode trade names and comparable A.W.S. designations. Part three is a dictionary of trade names, listing all of the trade names applying to the welding industry. This is followed by a Buyers' Manual, after which comes the ten-page general index.

## A.W.S. TO INCREASE ITS RESERVE FUND

The Board of Directors of the AMERICAN WELDING SOCIETY have felt that the reserve fund of the SOCIETY should be increased to at least the amount required for one year of operation. Accordingly, it is endeavoring to raise an additional $85,000 for its reserve fund through voluntary subscription on the part of its sustaining companies and sustaining members.

Some societies have built up their reserve funds through initiation fees and subscriptions. The AMERICAN WELDING SOCIETY does not have an initiation fee and its membership dues are moderate. During its twenty-five years of existence, the operation of the SOCIETY has required practically all of its funds to provide its services to its members.

However, the planning and thinking of the Board of Directors must of necessity be with an eye to a balanced financial operation. Experience has indicated that the SOCIETY'S revenue is subject to the same fluctuation as the business cycle. Therefore, to guard against interruption of its important activities, it is necessary to have an adequate reserve fund.

The welfare of the AMERICAN WELDING SOCIETY and its financial standing are of direct interest and importance to everyone interested in welding.

Members of the SOCIETY have every right to be proud of its accomplishments, which have been attained at an extremely low cost per member as compared with those of the ten principal technical societies. While it is hoped that the greater portion of the $85,000 mentioned above will be secured from the company members, nevertheless, the Reserve Fund Special Committee will welcome contributions from other companies and individual members. Such contributions would go a long way toward achieving the goal. This is a non-recurring request, which the U. S. Treasury Department has declared to be deductible expense for Federal Income Tax purposes.

Checks should be made out to the order of American Welding Society Reserve Fund Special Committee, and sent to A. W. S. headquarters, 33 West 39th St., New York 18, N. Y.

## A.S.A. STANDARDS

The American Standards Association has recently approved three specifications formulated by the American Society for Testing Materials, as American Standards.

The first of these, Low Tensile Strength Carbon-Steel Plates of Flange and Firebox Qualities (G30. 1-1943) A.S.T.M. A89-43), covers two grades of carbon-steel plate. This material is suitable for fusion welding and, if certain given requirements are met, for forge welding.

The second standard, Carbon-Silicon Steel Plates of Ordinary Tensile Ranges for Fusion-Welded Boilers and Other Pressure Vessels (G31. 1-1943) (A.S.T.M. A201-43), covers carbon-silicon-steel plates, in two ordinary tensile strength ranges designated grades A and B, intended particularly for fusion welding; and for use in locomotive boiler shells, boilers for stationary service and other pressure vessels.

The third standard approved, Low Tensile Strength Carbon-Steel Plates of Structural Quality for Welding (G40. 1-1943) (A.S.T.M. A78-43), covers two grades of carbon steel plates of a structural quality suitable for welding and, if certain specified requirements are met, for forge welding.

These standards may be obtained for 25 cents each from the American Standards Association, 29 W. 39th St., New York 18, N. Y.

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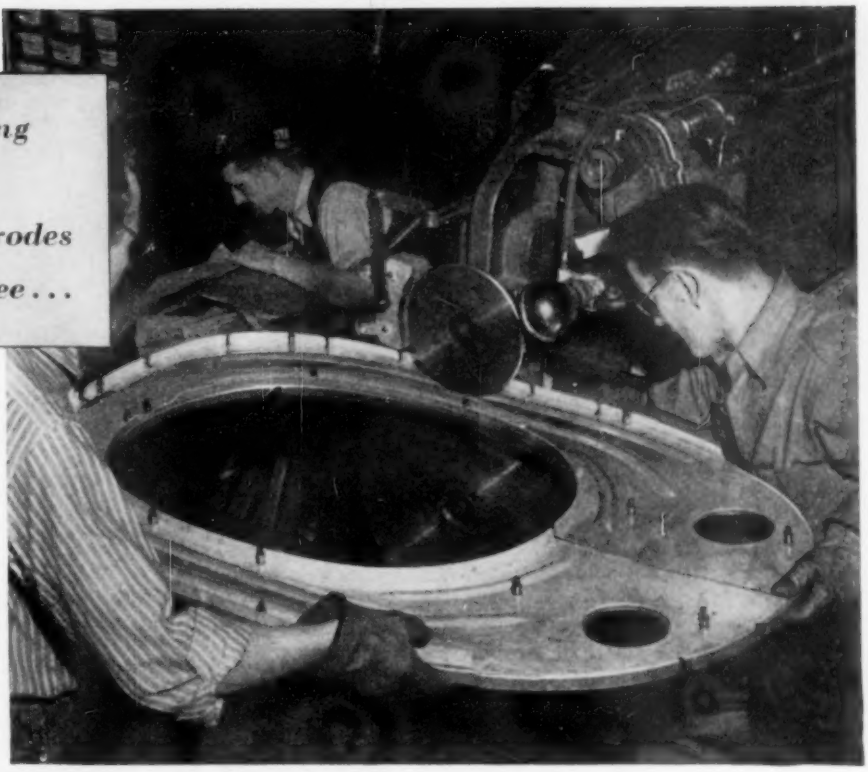
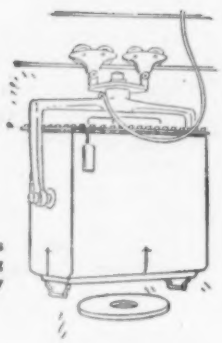
*The Most Important Thing*
*To Look for*
*in Resistance Welding Electrodes*
*is Something You Cannot See . . .*





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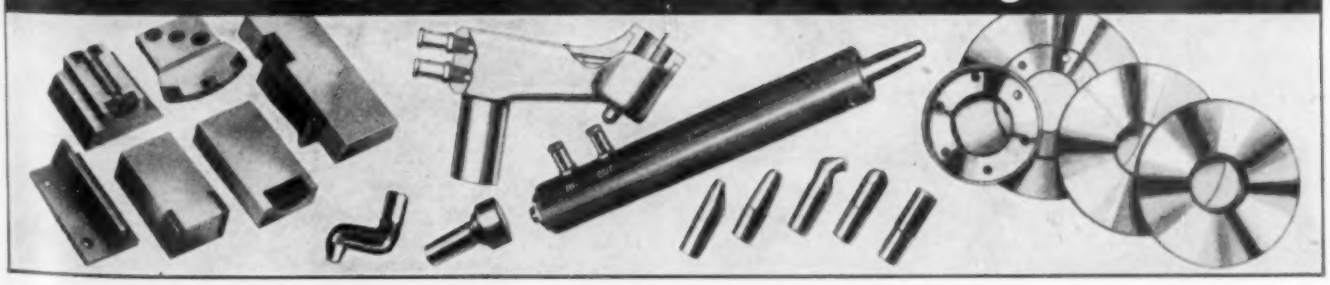

## ENGINEERING STUDENTS

Enrollment of college students will reach an all-time high in the years immediately following the war, Livingston W. Houston, executive vice-president of Rensselaer Polytechnic Institute, predicted at the annual mid-winter meeting of R.P.I. alumni in this New York City on February 5th.

He forecast that enrollment increases would be heaviest in engineering and science courses.

"I learned recently," he said, "that one university, having no engineering school, canvassed 377 trainees in a military training program on its campus and found that nearly half planned to go to college after the war and that more than 80% of these said they wanted to study engineering.

"This is just one instance of how the spectacular and dramatic achievements of engineering and science in the war have captured the imagination and interest of young men. Because this is a mechanized war, with amazing scientific devices and engineering feats, thousands of service men have become attracted to engineering and science and many will return as engineering students. In addition we shall have larger numbers of entering freshmen interested in engineering.

"Before the war not more than 5% of the public had any college connections. Through tuition-free war training courses conducted by colleges for the U. S. Office of Education, many thousands of men and women have had their first taste of the college classroom, and many of them will be more ambitious for their sons and daughters to have college training."

The executive said he expected that preceding the postwar rush even engineering colleges, whose student enrollments have been high, would experience a period of lower enrollment.

"This period will have its advantages, however, if it will give our faculties and administrators a breathing spell in which to appraise wartime educational experience and develop the best pattern for postwar engineering and science education," he said.

Dr. Ray Palmer Baker, R.P.I.'s dean of students, warned that in the "new testings and concepts of the postwar period old distinguished reputations of colleges and universities will not mean much. Indeed, we might say all will be starting from scratch. It will be a time of challenge and opportunity, and new names may well displace old ones as the leaders of the educational world."

Dr. Matthew A. Hunter, dean of faculty, reported on the fields of research and scientific development in which the Institute had engaged during the war. He said nothing could be described specifically because the work was secret or confidential.

## FUNDAMENTALS AND APPLICATIONS OF ELECTRONIC CONTROL

The fundamentals and the various applications of electronic control are interestingly described in a new 12-page bulletin (GEA-4126) recently issued by the General Electric Co.

Well illustrated, the publication explains in clear, simplified language the fundamental principles of electronic tubes and their operation, describes the construction of the well-known thyratron tube and lists the functions of eight of the more widely used industrial-type tubes.

The publication also describes and illustrates many practical application of electronic control, including rectification, resistance welding, timing and processing operations, as well as photoelectric installations involving counting, sorting, weighing, measuring, registering, illumination and the control of cement kiln temperatures. Many of these applications have been in successful operation for a decade or more.

Also listed in the publication are the various advantages afforded by the use of electronic control, such as flexibility, precise control, reduced maintenance, and quiet, faster, automatic operation.

## BULLETIN ON ELECTRONIC TUBES

A new quick-selection chart of electronic tubes for industry is contained in a new four-page bulletin (ET-12) being sent by the General Electric Co.'s Tube Div. to distributors for mailing to customers.

Copies of the bulletin are available free on request at the nearest G-E electronic tube distributor or the Advertising Div., Electronics Dept., General Electric Co., Schenectady, N. Y.


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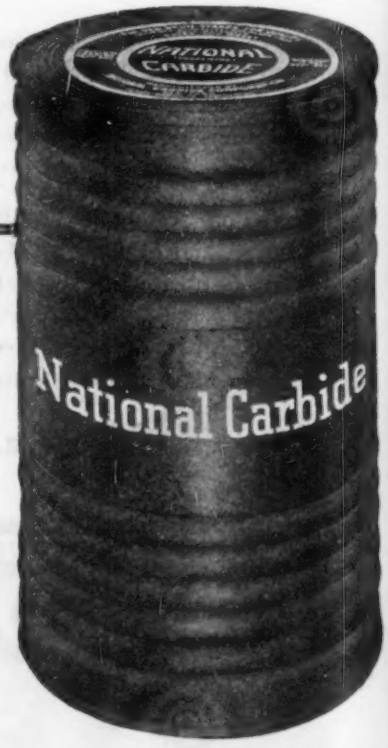


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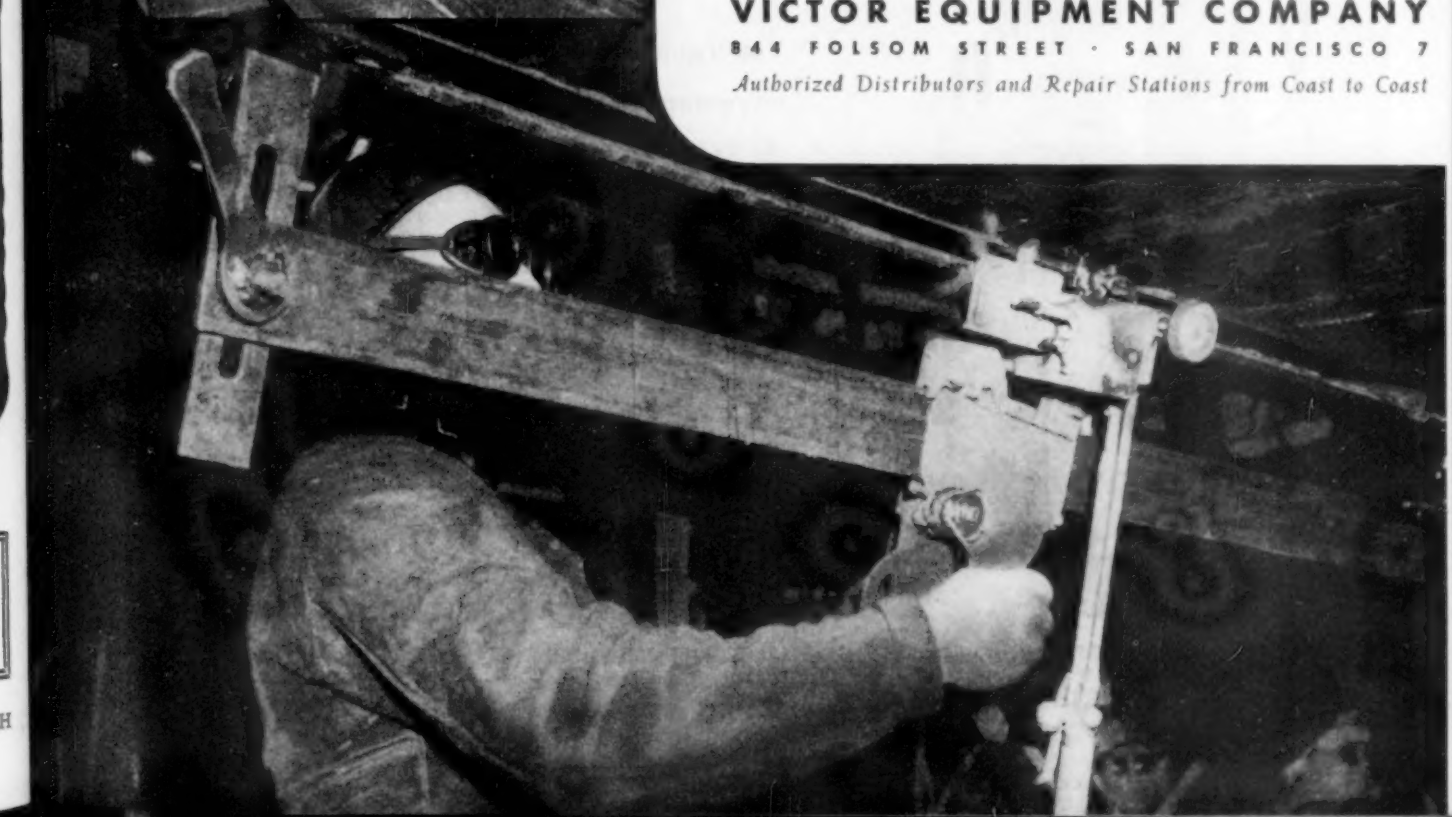


## SUSTAINING COMPANY

Cadillac Motor Car Division (General Motors Corporation), Detroit, Mich., is engaged in building the M-5 light tank and M-8 motor gun carriage, both powered with two Cadillac automotive V-type engines and Hydra-Matic transmissions. The success of these high-speed, sturdy vehicles on the battle fronts of the world have resulted in this Cadillac power train becoming the standard power for all light tanks. On land, on sea, and in the air, Cadillac products in wartime are living up to their peacetime reputation as "Standard of the World."

## SUSTAINING MEMBERS

The Griscom-Russell Co., Massillon, Ohio, has been a leader in the manufacture of heat transfer apparatus for 77 years. They have pioneered in the development of this type of equipment and its applications to heating, cooling, condensing and heat exchange processes in the petroleum refining, chemical, utilities, marine and general industrial fields.

Among the designs which this company has originated have been coil-type heaters, raw water evaporators, scale-shedding units, fin-type heat transfer surfaces with longitudinal, helical and conical fins, etc.

Joshua Hendy Iron Works, Sunnyvale, Calif. Founded 1856. Crocker-Wheeler Division, Ampere, N. J. Pomona Pump Division, Pomona, Calif. Manufacturers of marine turbines and gears, marine reciprocating engines, Diesel engines, turbogenerator sets, generators, pumps, hydroelectric equipment. Its 65-acre plant with five major shops and modern foundry has all facilities for every kind of heavy construction. Hendy engines power one-third of the Liberty fleet. Hendy mining machinery has been standard for many years.

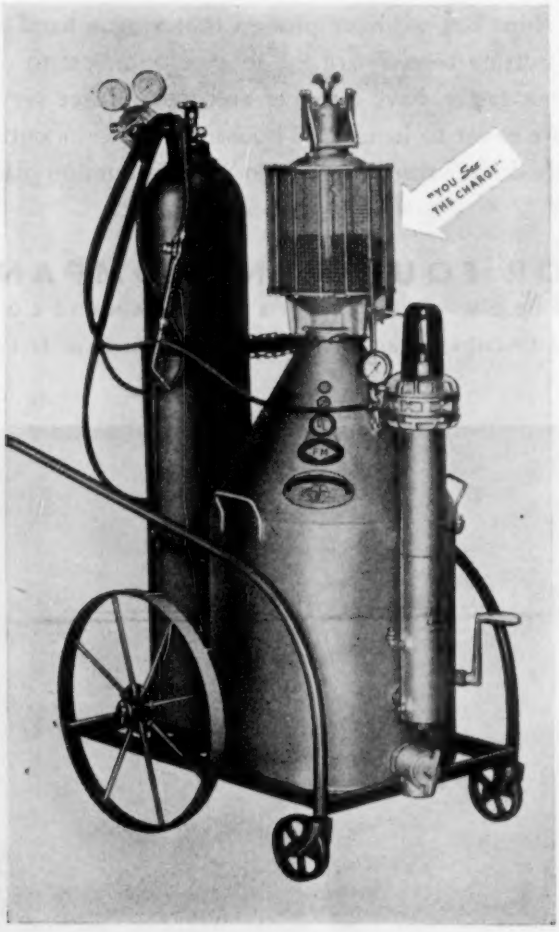
## AUSTIN VICE-PRESIDENTS

Roy E. Ward, district manager of The Austin Co. at Los Angeles since 1925, and Frank W. Maynard, the company's district manager at Oakland, Calif., since 1937, have been named vice-presidents of this national engineering and construction organization.

Mr. Ward, a native of Portland, Mich., was graduated from the University of Michigan in civil engineering. After seven years spent in structural design, plant layout work and the design of dams and power plants, he joined Austin in 1917. Following two years in its Philadelphia and Washington offices, he was named manager of Austin's materials sales division, which rendered engineering service and furnished structural materials for industrial plants erected in all parts of the world. He was named Cleveland district manager in 1924 and was placed in charge of all the company's activities in southern California as vice-president and general manager of its California subsidiary the following year. Mr. Ward is an associate member of The American Society of Civil Engineers and a member of the AMERICAN WELDING SOCIETY.

Roy E. Ward

Mr. Maynard was born in Worcester, Mass., and received his degree in civil engineering at Worcester Polytechnic Institute. He joined the Austin organization as an estimator in Philadelphia in 1917, spent a year in the Army Engineers Corps and returned to Austin in 1919. After five years in estimating and sales departments, he was named district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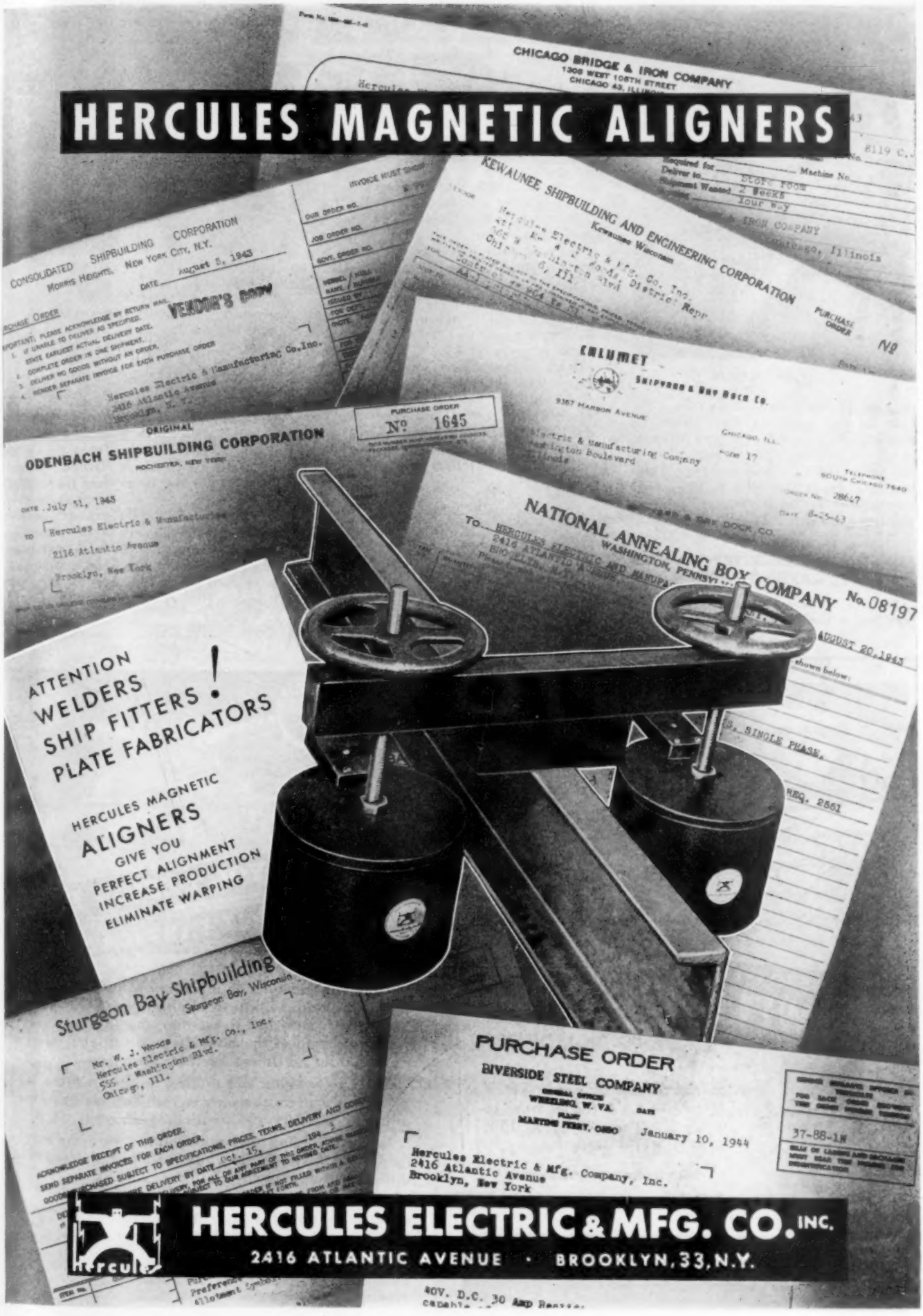
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Frank W. Maynard

engineer at San Francisco in 1924. Except for the past two years, when he was specially assigned as project manager in charge of design and construction of two large D.P.C. plants for Dow Magnesium Corp. in Michigan, he has served successively as sales manager, resident manager and district manager at Oakland.

### PENNSYLVANIA ENGINEERING WORKS PERSONNEL CHANGES

William S. Wheeler has been elected president of the Pennsylvania Engineering Works, New Castle, Pa., following the retirement of W. H. Lewis as president.

Mr. Lewis served as president of the Pennsylvania Engineering Works for over 19 years and remains with the organization as chairman of the board of directors.

William S. Wheeler joined the company in 1905 as a draftsman and served in all departments of the company and on his appointment to the presidency was vice-president and general manager.

Mr. Wheeler graduated from the University of Wisconsin receiving a degree in mechanical engineering. He is treasurer of the Steel Plate Fabricators Association, and a member of the Iron and Steel Institute, Iron and Steel Engineers, American Institute of Mining and Metallurgical Engineers, Engineers Society of Western Pennsylvania and the AMERICAN WELDING SOCIETY.

Other promotions were made among the officers who have had a long continuous service with the company: Clark Rossiter becomes vice-president and general manager; P. M. Pattison becomes vice-president and secretary; A. L. Davis becomes treasurer; H. L. McFeaters becomes chief engineer.

### ELECTRODE CATALOG

The Reid-Avery Co., Dundalk, Baltimore, Md., has just issued an unusually attractive pamphlet describing their various types of electrodes for welding mild steel, low-alloy steel, stainless steel, surfacing and gas welding rods. The engineering data published in this pamphlet will be useful to engineers and others concerned with welding. Copy available on request.

### ARMY-NAVY E AWARD

The Moeller Instrument Co. announces the receipt of the Army-Navy Production Award for Excellence in War Production.

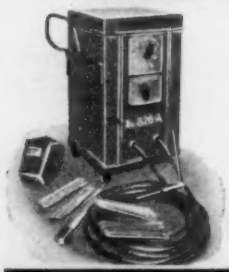
### BY-LAW REVISIONS

By-Law Revisions as published in the November Welding Journal and submitted for letter ballot vote on December 11, 1943 now stand approved and will be incorporated in the By-Laws appearing in the 1945 Year Book.

### THE AMERICAN HELMET

The McCord Radiator & Mfg. Co., East Grand Boulevard at Riopelle, Detroit, Mich., has published an unusually attractive pamphlet on the evolution of the New American Helmet. Pieces of edging for the helmet are made from stainless steel strips in a forming machine. This edging, cut to proper length, is spot welded around the edge of the helmet as it emerges from the spray. Metal loops for holding a chin strap are spot welded on to each side. The story of the New American Helmet was prepared by Daniel L. Wells.

WRITE FOR CATALOG



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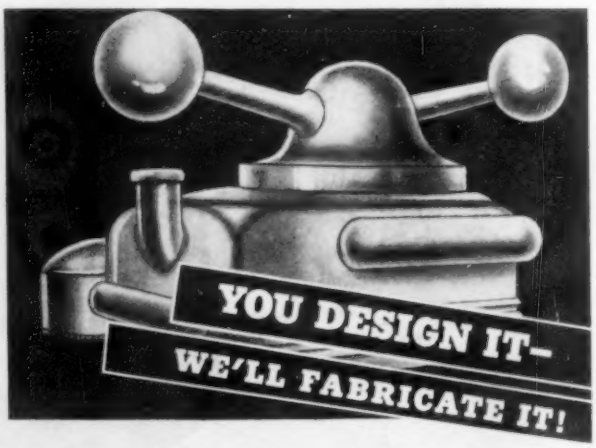


An unusual design...but not improbable. Stranger things than this will flash upon the post war scene. When such a design is created, the logical source for fabrication of the housing and various interior parts would be United Welding Company.

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### LINCOLN REPRESENTATIVE

Announcement has just been made by The Lincoln Electric Company of the appointment of R. H. Davies as welding engineering representative in Washington, D. C. He will be located at 410 Hill Building.

Davies has had wide experience in the industrial engineering field. He received his college education at the University of Minnesota after which he was employed by The Lockheed Aircraft Corp. where he worked as production engineer on the Lockheed "Hudson" and the first Lockheed "Lightning" aircraft.

R. H. Davies

He later became connected with Northrop Aircraft, Inc., starting at their new plant at Hawthorne, Calif., where he did considerable development work on the Northrop patrol bomber and "Flying Wing." He was given the assignment of developing all production and tooling methods for experimental and prototype aeroplanes and took an active part in the building of several confidential aircraft components of magnesium. Here he collaborated with V. H. Pavlecka in the development of the Heliarc welding process for magnesium.

Davies next became associated with Henry J. Kaiser where he was first plant engineer in the building of Kaiser's large magnesium plant, the alloy plant, the ferrosilicon plant and the magnesium sand-casting foundry at Permanente, Calif. After the construction period he was made superintendent and was also in charge of production and plant development.

### THE THUNDERBOLT

One of the mightiest sinews in the American air-arm also has been one of industry's mightiest problems.

The power plant of the world's heaviest, fastest single-seat fighting plane (the Thunderbolt P-47) rides on a slender, fragile-appearing tubular section called the engine-mount.

With design of the mount perfected and alloy steel available in quantities, the finished unit to hold the powerful Pratt and Whitney engine of the P-47 needed only sufficient skilled arc welders to meet the demands of the military.

**Welding Ring Brackets and Cowl Brackets on Engine Mounts Made by Carrier Corporation for P-47 Airplanes**

Carrier Corp. and other industries skilled in peacetime welding techniques were called in to build the mounts. Many relinquished their contracts after repeated rejections of the mounts because of "cracking" during the welding process.

The engine mount of a Thunderbolt must be perfection itself. The least defect in the mount would mean disaster as the power plant it carries develops greater speed at higher altitudes than any fighter plane of any nation. Racing at more than 400 miles per hour in substratosphere, subzero altitudes of 30,000 to 40,000 ft., the P-47 is nothing short of mechanical marvel.

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To prepare aluminum-clad steel sheets before spot welding, many plants are employing a NEW Oakite method specially designed for this work. This technique is proving remarkably effective and THOROUGH for quickly removing oil, grease, stamping compounds, identification paint and oxide films.
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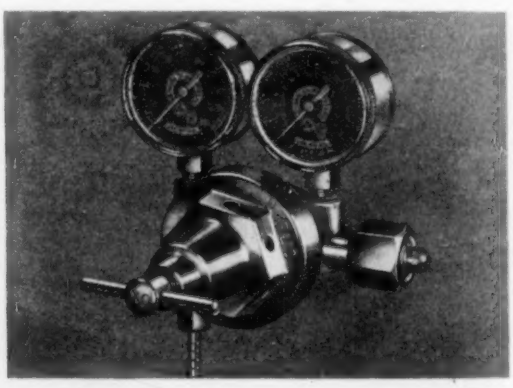

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# "When Women Welders Wear Comfortable AO Clothing They Feel Like Working"

These good looking clothes come in welder's leathers with a rich, soft suede appearance. And they're specially tailored to a woman's taste. Notice the trim fit? These clothes make women feel like working. Free-action lines help women welders to move around quicker with less effort. Tough, long-wearing chrome tanned cowhide gives better protection . . . helps *keep* women on the job.

Help your women welders work *easier*. Dress them up in AO style. AO's smart line of welders' clothing includes Tailored Coats, Short Jackets, Overalls, Sleeves, Aprons and a Turban to protect women's hair and ears while welding. Your nearest AO Branch Office can give you full details. Get in touch with them today.

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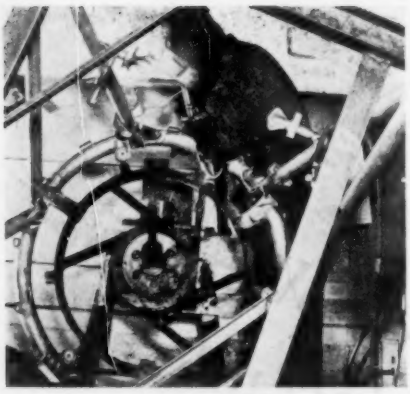

Solid Welding of Complete Assembly of Legs on Engine Mounts Made by Carrier Corporation for P-47 Airplanes

The famous Thunderbolt won its spurs on its first flight, May 6, 1941. The test pilot's cryptic "We've hit the jackpot" told the whole story.

Designed for offensive action as a bomber escort, to outrange and outclimb the enemy "heavies," the P-47 carries terrific firepower, increased ammunition loads and heavy armor for protection of the pilot.

Compared with ground weapons, Republic Aviation Corp. officials say: "It is as if we had been asked to build a heavily armored tank—with the speed of an armored car and superior firepower of a tank destroyer."

In describing the mount which carries the huge Pratt and Whitney engine, William H. Irwin, Supt. of Carrier Corp.'s Aviation Div., told of the problems involved in licking the cracks which result from the welding process.

Carrier experts decided upon the a.-c. type of welding transformer with an ionizer attached in order to accomplish three objectives—simplify the striking of the arc, get rid of the arc blow in tube clusters and tight corners, and control amperage setting.

Mr. Irwin said the causes of cracks fell in three categories: first, welding technique; second, contraction and expansion of heavy and light parts welded together; third, temperature and humidity variations in the welding room.

The first difficulty was overcome by instruction; for instance, starting the weld slightly in advance of the bracket and clip to be welded. Contraction and expansion were controlled by preheating to approximately 300°. And the last, air conditioning, was no problem for experts at Carrier.

## "WHITING AUTOMATIC WELDING CRANES"

A two-page, illustrated bulletin, Unit 68, has been published by Whiting Corp., Harvey, Ill., describing their special automatic welding cranes—a design developed by Whiting engineers to facilitate the handling of large welding jobs.

All interested persons will be sent a copy of this bulletin on request. Write for Unit 68.

## INTRODUCTION TO FERROUS METALLURGY

*Ferrous Metallurgy*, Vol. 1, by Ernest J. Teichert, Supervisor of Metallurgy Extension, The Pennsylvania State College currently metallurgist, E. G. Budd Mfg. Co.

This is the first book of a three-book series prepared by E. J. Teichert, to provide a three-year course of training for persons interested in the iron and steel industry. It covers those fundamentals essential to an understanding of the work to follow and includes the primary processing of iron ore in the blast furnace and the manufacture of cast iron, wrought iron and crucible steel.

Published by McGraw-Hill Book Co. Inc., New York and London. Price $4.00.

## X-RAY BULLETIN

A new copiously illustrated 20-page technical bulletin describing the Picker 250-Kv. Industrial X-Ray Unit has been issued by the Picker X-Ray Corp., 300 Fourth Ave., New York, N. Y., and is available on request.

## McKAY ANNOUNCES NEW GENERAL SALES MANAGER

The McKay Co., Pittsburgh and York, Pa., recently promoted Fred C. Smith, with the company since 1927, to the post of General Sales Manager of all divisions of products. Mr. Smith's advancement with the company has been steady, having


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Familiar with pressure vessel construction and welding codes. Must have ability to train new employees, set up production work and handle men.

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Good permanent position with an expanding war-peacetime industry. Reply should give complete experience, current and past employers, salaries, etc. Box *V-136.*



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4. Deteriorated cast iron can be welded with "York's 77".

*Send for FREE sample.*

# PAGE *Welding* ELECTRODES

*The coating on PAGE Shield Arc Electrodes is constantly checked for uniformity*

## THE UNIFORM COATING ON PAGE-*Allegheny* STAINLESS STEEL ELECTRODES HELPS YOU CONTROL STAINLESS WELDS

When welding Stainless, to get the proper deposit in the weld, the arc must be maintained, the rate of deposition must be high, penetration must be uniform and atmospheric contamination must be prevented.

The analysis of the rod and the type of coating have considerable bearing on the results. That is why **PAGE** worked with the world's largest producer of Stainless Steel to make certain that **PAGE**-*Allegheny* **STAINLESS STEEL ELECTRODES** would be right.

But **PAGE** experience with this complete line of Stainless Electrodes soon established that, to meet all the "musts" of good welding, very little variation could be tolerated in the *thickness* of the coating because the coating has so much to do with those vital characteristics.

Consequently, when you get **PAGE**-*Allegheny* **STAINLESS STEEL ELECTRODES** from your **PAGE** jobber, **PAGE** inspection has made certain that the coating on them will be uniform in thickness.

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**Monessen, Pa., Atlanta, Chicago, Denver, Los Angeles, New York, Pittsburgh, Portland, San Francisco**

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**ESSENTIAL PRODUCTS**...TRU-LAY Aircraft, Automotive, and Industrial Controls, TRU-LOC Aircraft Terminals, AMERICAN CABLE Wire Rope, TRU-STOP Brakes, AMERICAN Chain, WEED Tire Chains, ACCO Malleable Castings, CAMPBELL Cutting Machines, FORD Hoists, Trolleys, HAZARD Wire Rope, MANLEY Auto Service Equipment, MARYLAND Bolts and Nuts, OWEN Springs, PAGE Fence, Shaped Wire, Welding Wire, READING-PRATT & CADY Valves, READING Steel Castings, WRIGHT Hoists, Cranes . . . *In Business for Your Safety*

occupied successively the positions of Statistician, Sales Correspondent, Sales Promotion Manager, Assistant Sales Manager and now General Sales Manager in the past 17 years. Born September 28, 1904, Mr. Smith was educated in Pittsburgh graduating from Carnegie Institute of Technology in 1925 with an engineering degree. Two years later a Master's Degree in Economics was conferred upon him by the University of Pittsburgh.

## WELDING REPAIR ON THE HIGH SEAS

In writing to S. Craig Cairns, Editor of "Hobart Arc Welding News," George Chitarovich with the 84th Naval Construction Battalion somewhere in New Guinea tells of an experience with Welding repair while on the high seas.

We quote from Mr. Chitarovich's letter as follows:

"We read the 'Hobart Arc Welding News' over here and thought you would be interested in one of the most extraordinary welding jobs completed while at sea. I have been in the Seabees 9 months overseas and our outfit has been doing an excellent job with the help of the two 300-amp. gasoline engine driven arc welders that is part of the equipment of our platoon.

"On one occasion when 10 miles from shore, 'An Incident' happened—well, anyway, a hole was blown in the side of our Navy LST (Landing Ship-Tank) just 2 ft. above the water line. The C.O. called me on the job to determine whether the repair could be made en route or should we put in for shore. I asked permission to attempt the repair at once.

"Since the hole was very rough and jagged, I first burnt out the hole to a 5-ft. square opening. I had counted on using some armor plate for the patch but found that it was the in hold of the ship and impossible to get at. We carry pontoons on deck that are 1/4 in. thick, so we cut up one of these pontoons to fit the square opening that I had cut and then did a leak-proof job of welding with one of the welders that we carry up on top deck.

"After completing this much of the job I suggested to the officer in charge that we weld another pontoon plate on the inside to reinforce the first plate, as the patch would be from 2 to 4 ft. below the water line when the deck load would be twice that which we were carrying. This second plate was welded under very tough conditions as the ship was heaving around from the swells of the sea.

"Later on, I was asked why I had put the second plate on the inside rather than on the outside overlapping the first plate. As there was not much pressure on the plate itself, I was anxious to do a neat job on the patch and if the plate had been lapped on the outside it would have appeared as really a patch job. These boys of the LST's are mighty proud of their ships and we Seabees, too, are always proud of our work. She's still going strong, delivering men, tanks, guns and supplies and from outward appearances, no one can hardly observe that we were ever the victims of 'An Incident.'"

## USE OF LARGER ELECTRODE SIZE EFFECTS $2800 SAVING IN SHEEP FOOT ROLLER CONSTRUCTION

Some of the largest sheep foot rollers or earth-tamping units ever constructed are being built at an estimated saving in deposited weld metal of $2800 by using the largest practical size of electrodes for the complete job which requires a total of about 40,000 lb. of electrodes, according to data received by The Lincoln Electric Company, Cleveland, Ohio.

*Official U. S. Navy Photograph, Courtesy Hobart Bros. Co.*

**LST's Carry the Goods to Rendova**

Side by side, two of the Navy's new landing ship-tanks (LST) unload their cargos of the materials of war on Rendova Island in the central Solomons. The Rendova action was a prelude to capture of Munda.


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**The Trade-Name is "ANTI-BORAX"**

*Ask for Them* *Unequalled for Quality*

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## VOLT-O-MATIC CONTROL

**QUICKLY CONNECTED** to *any* alternating current welder, G-R *Volt-o-Matic* control accomplishes these important functions:

**1. Automatically reduces open-circuit voltage** to *less than 10 volts* during non-welding periods. Welders can change electrodes without a "sting"... even when they're working in the rain!

**2. Accurately records arc time** in hours and tenths of hours. Readings at end of each shift provide a record of actual arc time for each machine... quickly spot lost time, permitting you to rearrange schedules to get the most out of every welding machine. By checking rod issued, less stubs returned, and comparing net rod used with arc time recorded, you can accurately determine amount of weld metal deposited. Reports from shipyards and other fabricators using G-R *Volt-o-Matic* control show that this "production control" has helped increase welding output as much as 20 per cent!

• • •

**Give your welders a break . . .** save hours and dollars on welding operations... by equipping your A. C. welders with G-R *Volt-o-Matic* control NOW!

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### FOUR MODELS

**AC-1**... Primary contactor, control relays, G-R *Time-o-Matic* relay with adjustable delay, control transformer and arc time totalizer, all mounted in sturdy weatherproof steel housing and completely wired.

**AC-2**... Same as above, less time totalizer.

**AC-3**... Same as AC-1, less primary contactor. (For use where contactors are already installed.)

**AC-4**... Same as AC-2, less primary contactor.

**For use with all A-C welders and all standard line voltages ... Quick and easy to install.**

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**NOTE:** The *Volt-O-Matic* control is a product of the G-R Electronics Division; it is standard equipment on Model 49 G-R welders; optional on all other G-R models.

*See your nearest G-R Distributor*

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An outstanding example of the arc-welded type of structure, this item of equipment, being built at American Steel Works, Kansas City, Mo., was carefully designed to take full advantage of the many benefits to be gained with the welding process.

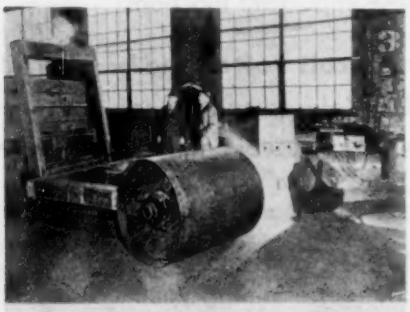
Each unit consists of three tamping rollers arranged side by side within separate frames which in turn are fastened to a heavy draw bar 120 in. in width, with a tubular bar of similar length at the rear.

An interesting feature of the job is that the individual structures must be absolutely water-tight as either water or sand is carried within the rollers and hollow members to add extra weight.

One phase of the construction operation is shown in Fig. 1 where two operators are working on production of the frames. This particular part of the unit is made of 1/4-in. plate with 1/2-in. plate reinforcements at the connections. All welding is done by positioning the work for most efficient, high-speed welding at the joints.

Figure 1 also shows one of the rollers before welding on the feet or tampers. This drum-like structure has 3/8-in. shaped plate for the body with 1/2-in. plate for the heads which are recessed into the body and fillet welded all around as indicated in this view. Hubs for the axle and a seat for the inlet nut are also welded to the head as indicated in this view, after three stiffeners have been welded inside. Each unit is air tested to assure a leak-proof structure.

Fig. 1—Fabricating the Frames for Huge Tamper Units by Arc Welding. One of the Partially Completed Rollers Is Shown in Center, Ready for Welding on the Feet



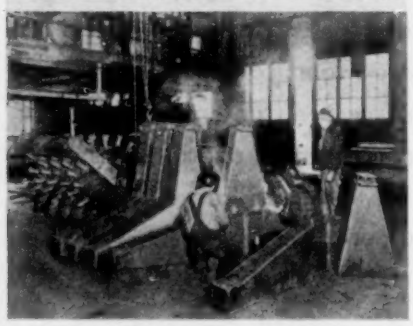


Fig. 2—Arc Welding the Drawbars for the Triple-Roller Tamping Unit. A Completed, Single-Roller Assembly with Frame in Place Is Shown in Background

Construction of the drawbars, shown in Fig. 2, illustrates how these units are assembled of standard pieces of 1/4-in. plate, cut to shape and fused into a single T-shaped structure. Corner, butt and fillet welds are used with two operators working at a time on one unit to speed up production. Over-all dimensions of the drawbar are 12 x 60 1/2 in.

All welding is done with 1/4-in. electrode for mild steel, all position. A considerable savings in cost of deposited weld metal was said to be effected by the firm by using 1/4-in. electrodes—the largest size practical—instead of a smaller size electrode such as 3/16-in.

## OBITUARY

### Lawrence H. Dunham

Lawrence H. Dunham, assistant manager of the Metallurgical Department of the American Steel & Wire Co., died suddenly in Pittsburgh, Pa., early January 19, 1944.

Mr. Dunham was born in Chicago, Ill., on August 21, 1891. After finishing high school, he attended the University of Illinois from which he was graduated in 1915 with a B.S. degree, having majored in Chemical Engineering and Metallurgy. Mr. Dunham began working for the American Steel & Wire Co. in December 1916 as a laboratory assistant in the Physical Laboratory in Cleveland, which position he held until he was made laboratory director in 1919. In 1928, he was made assistant to the chief metallurgist in the Main Office in Cleveland. In October of 1937, Mr. Dunham was transferred to the Chicago District of the Wire Company as a district metallurgist and three years later was made works metallurgist at the Waukegan, Ill., Works. Mr. Dunham was made assistant manager of the Metallurgical Department in April 1942.

Mr. Dunham was a member of the American Iron and Steel Institute, the American Society for Testing Materials and the AMERICAN WELDING SOCIETY. He was also a member of the Lakewood Lodge, No. 601, F. & A. M., the Eastern Star and Phi Lambda Upsilon, college fraternity.

Surviving him are his wife, Alsia, and two children, Doris Jean, a teacher in Ashland, Ohio, and Lawrence, member of the U. S. Army Air Corps. The Dunham residence is at 13899 Clifton Blvd., Lakewood, Cleveland, Ohio.

# Employment Service Bulletin

## SERVICES AVAILABLE

A-469. Twelve years' practical experience in welding, including pipe-line, building and bridge construction. Also two years' vocational school. Capable of taking charge of men and can guarantee production results.

A-470. Associated with the welding industry for the past ten years in the capacity of welder, instructor and more recently as welding engineer. Experienced in heavy plate, sheet metal, alloys, automotive and maintenance. College graduate. Can comply with W.M.C. regulations.

## POSITION VACANT

V-136. Wanted Welding Supervisor. Familiar with pressure vessel construction and welding codes. Ability to train new employees, set up production work and handle men. Knowledge of production methods in welding with a.-c., d.-c. and automatic equipment. Permanent position with an expanding war-peacetime industry. Give complete experience, current and past employers, salaries, etc.

## X-RAY AND RADIUM PROTECTION

Latest technical literature on X-ray and radium protection, together with lead products catalog is available upon request to Bar-Ray Products, Inc., 209—25th Street, Brooklyn, New York. Included with this material is the comprehensive data of the United States Bureau of Standards on X-ray protection which covers general recommendations, electrical protection, equipment, film storage, and a wealth of other valuable information.

## ELECTRODE CHART

The Anthony Carlin Company, 2717 East 75th Street, Cleveland, Ohio, announces that it has just published a new Electrode Comparison Chart, which is available without charge to welding executives and purchasing agents. The chart is printed in two colors on durable cardboard stock, letterhead size. It shows at a glance the scope of application of each of the company's line of PERFECTION" Welding Electrodes and shows the classification of each electrode under A.W.S.-A.S.T.M. Specification A-233, and what the corresponding designations are for other makes of electrodes. The data include several new electrodes which have recently been added to the Perfection line.


**ELECTROLOY ALLOYS for RESISTANCE WELDING ELECTRODES and DIES**

Spot
Seam
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ELECTROLOY ALLOYS were developed specifically for the resistance welding industry. ELECTROLOY ALLOYS cover the full range of physical properties necessary to the manufacturers and users of resistance welding equipment.

Our engineers will be glad to make recommendations for your special electrodes. Submit samples or specifications.

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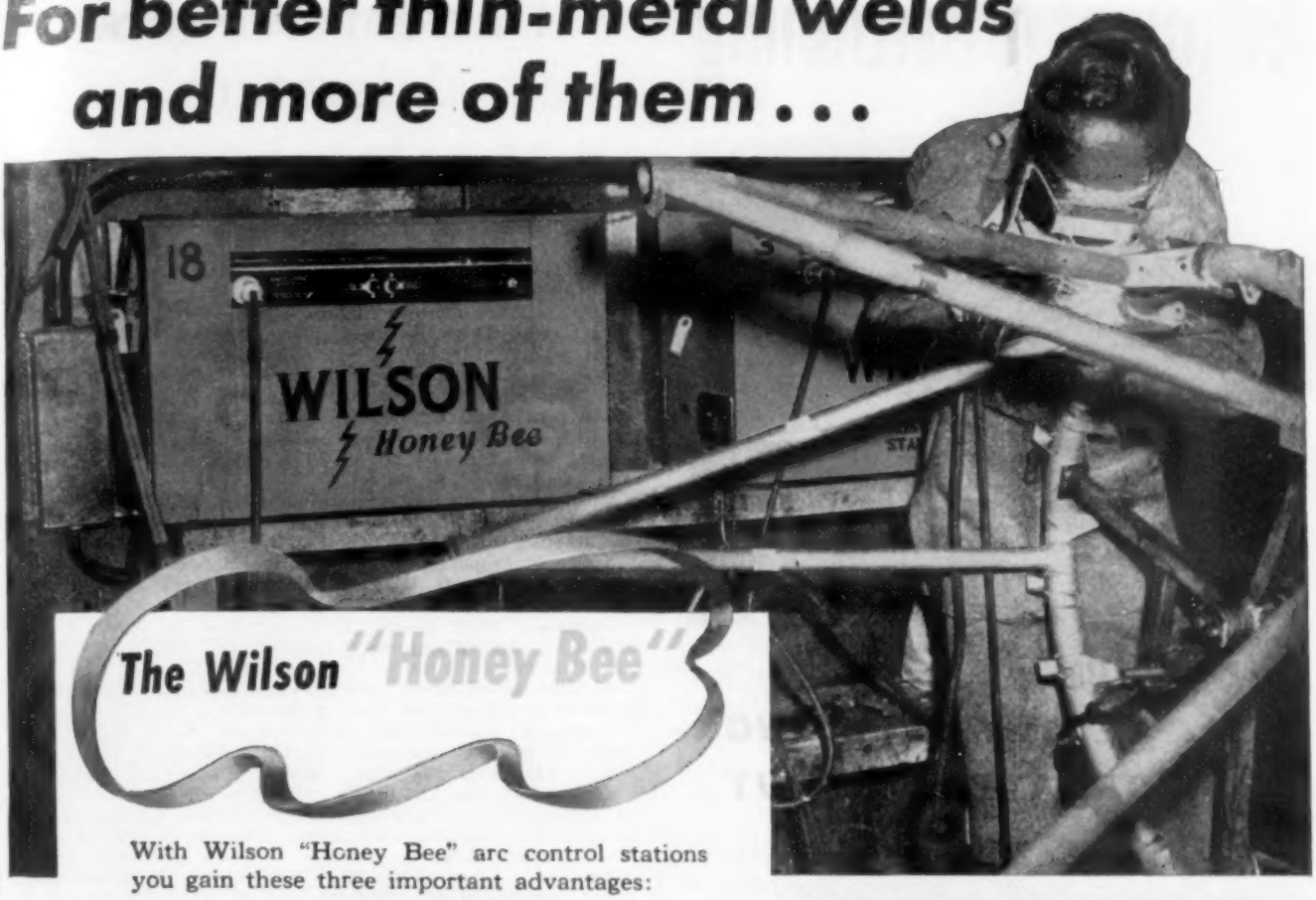
# For better thin-metal welds and more of them . . .

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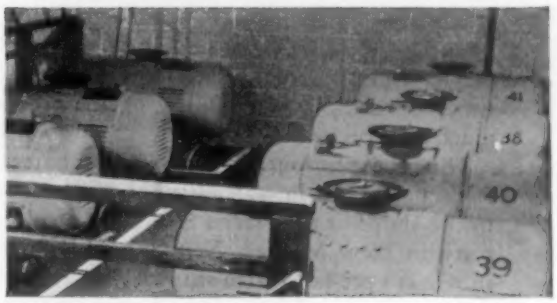
With Wilson "Honey Bee" arc control stations you gain these three important advantages:

1. **BETTER QUALITY WELDS ON THIN METAL** through the "Honey Bee's" Remote Crater Control, a motor-driven device which enables the operator to fade out the arc slowly over a mechanically regulated time interval. It operates automatically when actuated, thus providing uniform arc fade-out and effectively preventing craters and porous welds.

2. **MORE ARCS PER GENERATOR** since two or more "Honey Bee" stations are operated from each constant potential generator, thereby multiplying the job-capacity of each generator.

3. **MORE PRODUCTIVE TIME** through Wilson Remote Arc Control which permits each operator to regulate current from zero to maximum while welding – without first extinguishing the arc.

All these features combine to make the "Honey Bee" a valuable aid to productive quality welding on thin metals. The "Honey Bee" is made in 75 amp. and 150 amp. sizes. For full details write to Wilson Welder and Metals Company or to any Air Reduction Sales Office.




**IDEAL POWER SOURCE** for "Honey Bee" stations is the popular Wilson "Hornet". Long favored for its outstanding all-around performance, the "Hornet" gives excellent service when operated as a constant potential generator. With a convenient quick-change switch, the "Hornet" may be quickly changed from standard to constant potential characteristics, and vice versa as required.

*Photos courtesy of North American Aviation, Inc., of Kansas*

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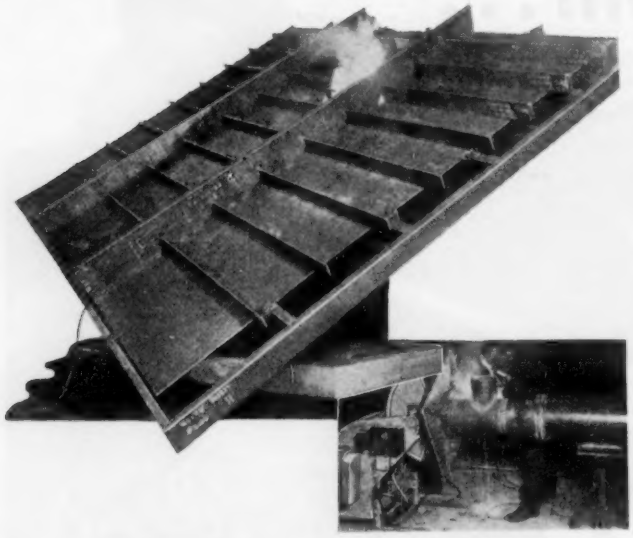
# Efficient Positioning



Method used in a shipyard for welding high pressure pipe.

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## BETTER WELDING and GREATER OUTPUT

When weldments reach these proportions, Welding Positioners become a necessity, especially when stronger welds and speedy production are essential. Welding large structures on the floor wastes time and reduces welding speed. Crane time, critical in most shops, is lost through much unnecessary handling.

The large photograph shows how a battery of Ransome 16,000 lb. capacity positioners is used in the shops of the Harris Structural Steel Company in New Market, New Jersey. The work shown is a pre-fabricated ship section. Notice the holding cradle which is bolted to the positioner table top. The weldment is quickly clamped to the cradle for all down-hand position welding.

Our engineers will be glad to help with your positioning welding problems. Industrial Division, Ransome Machinery Company, Dunellen, New Jersey.

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**Ransome WELDING POSITIONING EQUIPMENT**

WP43

Capacities 500-lb. to 40,000-lb., hand-operated and motor-operated . . . Head-stocks and Tail-stocks . . . Turning Rolls


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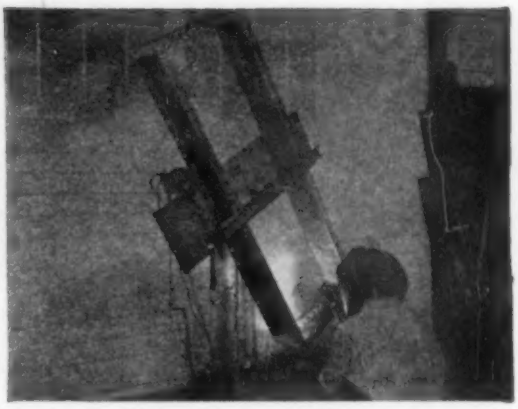
Electric Welding, Arc, Heliarc Process. Arc Welding of Mag-

(*Continued on page 294*)

It has always been the policy of the Metal & Thermit Corporation to pay special attention to the development of electrodes for welding special steels. Murex Carbon Moly. 50, Molex and Type M, for example, are outstanding in their performance for welding carbon-molybdenum steel plate, castings, high pressure, high temperature piping and pressure vessels. Murex R.C. and C.F., for the repair and welding of air-hardening steel castings are among the electrodes developed to meet the needs of war production.

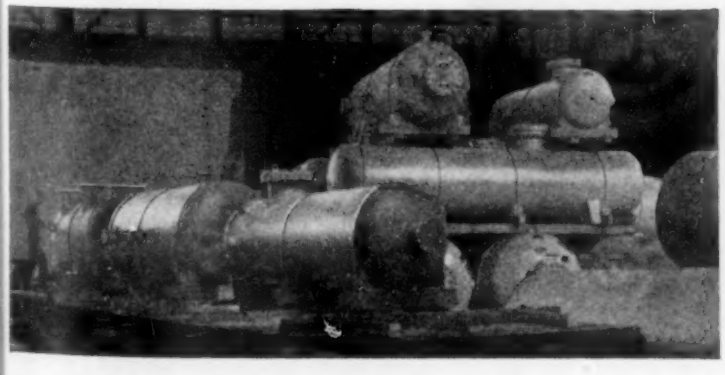
As the electrode requirements of fabricators change with the advent of industrial conversion, suitable Murex Electrodes will be available.



**PROVIDING HEAT AND FRESH AIR FOR OUR COMBAT VESSELS,** these heating units, produced by McQuay, Inc. of Minneapolis, must be rugged to withstand gunfire shock and near miss bomb concussion. To combine sturdy construction with light weight, welded construction using Murex Electrodes was adopted for the heater casings.

**HUGE TURBINES FABRICATED WITH MUREX ELECTRODES** by S. Morgan Smith Company, world's largest exclusive turbine builder. The illustration shows welding of a three-way branch inlet of a Vertical Impulse Turbine. Advantages of arc welding are: elimination of possible defects of complicated castings; less metal used; figuring of exact weights possible, thus enabling manufacturer to keep within estimates. Down-hand Murex Electrodes are used.

**THIS 7½-TON STEEL CYLINDER** on an 800-ton hydraulic press developed a crack 20 inches long and after preparation for welding 3 inches wide, and from 4½ to 6½ inches deep. Preheated 9 hours at about 700° F., this temperature was maintained during 17 hours of continuous welding with Murex Type F ¼ inch rods. The Detroit & Cincinnati Welding Company report that cylinder wall distortion was only about .0015" and that the flange moved only .004".



**PRESSURE TANKS FOR HIGH OCTANE GAS,** produced in quantity by The Bigelow Company of New Haven, Connecticut, are welded with low alloy Murex Electrodes to withstand pressures of from 100 to 600 pounds.

MUREX
ARC WELDING ELECTRODES
•
METAL & THERMIT CORPORATION
120 Broadway, New York 5, N. Y.
ALBANY • CHICAGO • PITTSBURGH
SOUTH SAN FRANCISCO • TORONTO
*Specialists in welding for nearly forty years. Manufacturers of Murex Electrodes for arc welding, and of Thermit for repair and fabrication of heavy parts.*

# NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

### X-RAY TESTING HELPS SPEED CONSTRUCTION

Engineering ingenuity and daring, demonstrated in the successful application of X-ray to steel welding at dizzy heights is disclosed by the Kelley-Koett Mfg., Co., Covington, Ky., in describing an accomplishment that has proved much favorable comment in construction circles.

As a result of the successful use of X-ray testing, it was possible to complete the "Baltimore Giant," a fluid catalyst-cracking unit at the Standard Oil Co. of New Jersey's refinery in Baltimore without welding defects.

Construction engineers of the M. W. Kellogg Co., general contractors and engineers for the "Baltimore Giant," were asked to X-ray all welds in the huge plant.

This was the result of the Standard Oil management's desire to have a composite survey of the 250-ft. high "Giant"—a key unit in a $14,000,000 modernization program, through which thousands of barrels of high-octane aviation gasoline are available daily for the war effort.

Technical experts of the Kelley-Koett Co. working with the Standard Oil Development Co. and the Kellogg organization "stripped down" a standard 220,000-v. X-ray unit made by the Covington concern. After fitting the unit to special rigging, the equipment was crane-hoisted from level to level.

Despite rainstorms and unavoidable jars and jolts, the X-ray testing of welds in awkward locations went forward successfully and is believed to be another indication for postwar X-ray applications in shipbuilding, plant construction and other "heavy industry" uses.

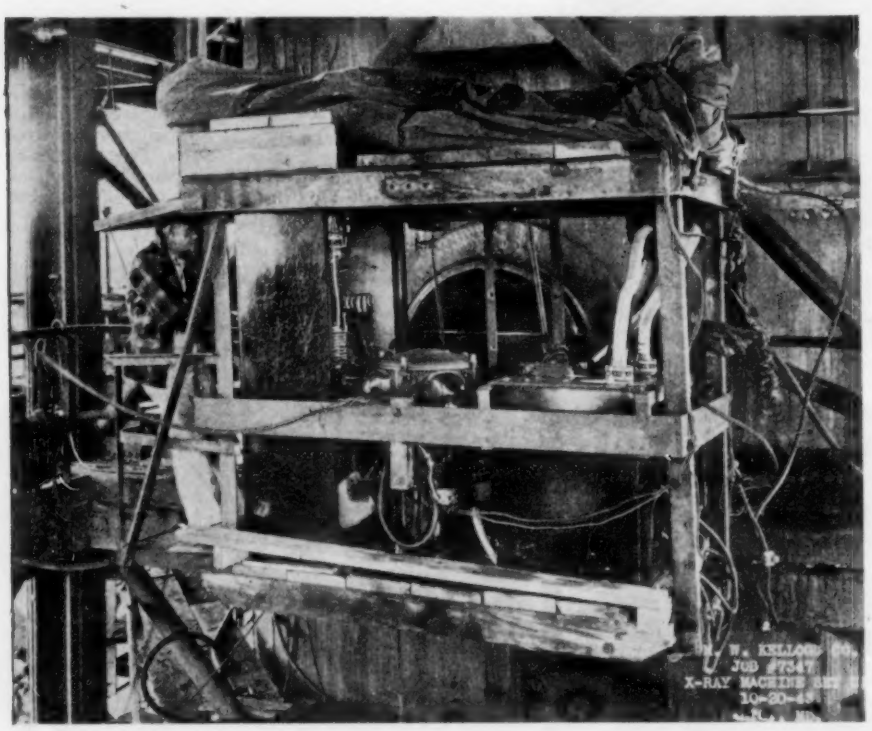
### NEW ALL-WEATHER A.-C. MACHINE

Wilson "Bumblebee" a.-c. welders are now available in all-weather models of 300- and 500-amp. capacities. These machines are similar to the standard Wilson "Bumblebee" a.-c. welders, except that they have special moisture-proof insulation throughout, and all parts are protected by a heavy coating of moisture-proof paint. The outer case is finished in a durable weather-resisting enamel and has gaskets and louvers designed to prevent entrance of rain.

In addition, the all-weather Wilson "Bumblebee" is equipped with a low-voltage contactor which automatically

holds the open circuit voltage at approximately 40 v. When the operator strikes the arc, the low-voltage contactor closes instantly and the transformer's performance thereafter equals that of machines not similarly equipped. When the arc is extinguished, this device immediately reduces the voltage back to 40 v.

In all other respects, these all-weather models offer the same features as the standard Wilson "Bumblebee"—wide current range, high electrical efficiency, improved power factor and easy maintenance. All-Weather "Bumblebee" a.-c. welders are manufactured by Wilson Welder and Metals Co., Inc., 60 E. 42nd St., New York, N. Y. They are distributed by Air Reduction Sales Co., with offices located in all principal cities throughout the nation.



**X-ray Machine Set Up Ready for Action**

Transformers, etc., are stripped of protective covers to reduce weight. The only protection against the elements is tarpaulin shown rolled up atop the suspended crib.

### "FROSTPOINT" ELECTRODES IN AIRCRAFT WELDING

Faced with the necessity of joining together more individual pieces per pound of finished product than any other manufacturer of transportation equipment, the aircraft industry is apparently finding the answer to many of its aluminum spot-welding headaches in the new "Frostpoint" type of refrigerated electrode, a survey of leading aircraft and aircraft subassembly producers reveals.

The "Frostpoint" electrode (see Fig 1), manufactured by Frostrode Products, 19003 John R St., Detroit 3, is so designed that its coolant tube concentrates all cooling effect in the electrode proper, eliminating losses caused by trying to refrigerate holders and welder arms. Each electrode is a permanent installation and is tipped with a quickly replaceable "Frostcap."

This cap is cold forged from electrolytic copper for higher conductivity and internally finned to produce maximum cooling area. The structure of the cap does away with much of the metal separating the working face from the coolant, thereby bringing the coolant closer to the source of the heat than the conventional type of refrigerated electrode does. Thus the face of the "Frostpoint" electrode is effectively cooled right where the cooling effect is most needed. When

## PROVE THEIR WORTH ON THE TOUGHEST JOBS

### RACOLLOY 19-9

For the all-position welding of certain high-tensile, low-alloy, air-hardening steels, use Racolloy 19-9 Stainless Electrodes. The superiority of Racolloy 19-9, as of all Raco products, is assured by the most minute laboratory control throughout the entire production cycle.

RACOLLOY 19-9 Electrodes conform with Ordnance Specification AXS-886 ... U. S. Navy Bureau of Ships Specification 46E4 (INT)—Grade V, Classes 1, 2 and 3

### RACOLLOY 25-20

For the all-position welding of austenitic, corrosion and heat-resisting steels, use Racolloy 25-20 Scale-Resisting Shielded-Arc Electrodes. While specially designed for such work, they may be successfully used on high-tensile, low-alloy, air-hardening steels.

RACOLLOY 25-20 Electrodes conform with U. S. Navy Bureau of Ships Specification 46E4 (INT)—Grade IV, Classes 1, 2 and 3.

# REID-AVERY COMPANY

DUNDALK BALTIMORE 22 MARYLAND

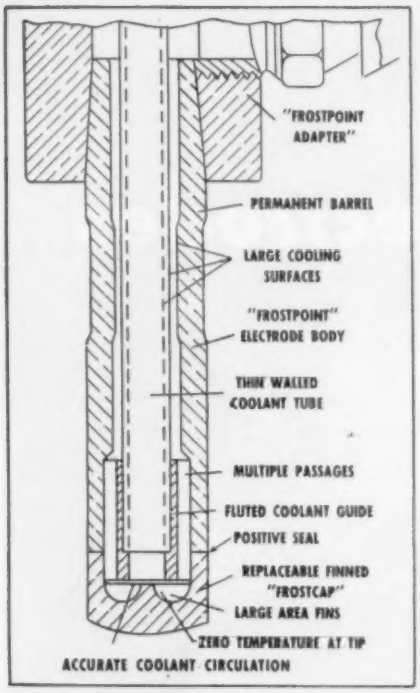



Fig. 1

one "Frostcap" is consumed, another one is easily slipped onto the permanent electrode. As the life of one "Frostcap" has been found to be approximately equal to that of the conventional electrode, this feature cuts replacement costs to a small fraction as well as conserving 90% of the copper used in the electrode.

## A.-C. WELDING OF THIN AIRCRAFT METALS

Welding of thin metals—so much of which is being done by aircraft builders—requires small electrodes. Low Welding currents are also necessary to keep from burning the thin sheet, according to Westinghouse engineers. Under these conditions, the a.-c. arc becomes unstable and tends to go out easily, frequently spoiling the weld.

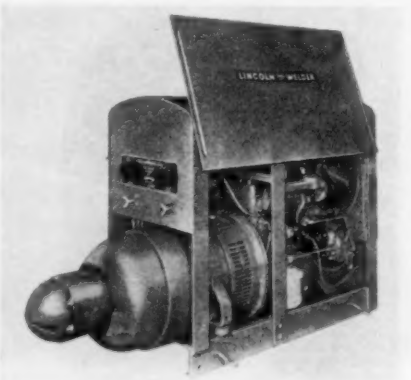
Gas has been used to some extent for this sort of work—it is fast but more expensive. D.-c. welding was not feasible because of arc-blow difficulties. Not only that, the greater penetration of d. c. often led to burning through the thin metal.

The problem was solved by superimposing a high-frequency voltage wave (about 250 kilocycles) on the welding current. This high-frequency voltage keeps the arc steam ionized during the reversals of low-frequency (60-cycle) welding current. Functioning as an arc stabilizer, the high frequency provides firm control of very small welding currents. This new welding development has greatly expedited plane production and the manufacture of other devices from thin-gage metals.

## ENGINE-DRIVEN ARC WELDER

A new "Shield-Arc" engine-driven welder rated at 200 amp. of lightweight, rugged construction with powerful enclosed, rubber-mounted engine of 29 hp., is announced by The Lincoln Electric Co., Cleveland, Ohio.

This new unit, supplied complete with base and canopy (see accompanying photograph), has a current range of 40 to 250 amp. Dual control of welding current is accomplished by adjustment of series fields and generator speed.



**New Lincoln Welder, Engine Driven, of 200-Amp. Capacity and Embodying Innovations in Design to Increase Usefulness and Efficiency**

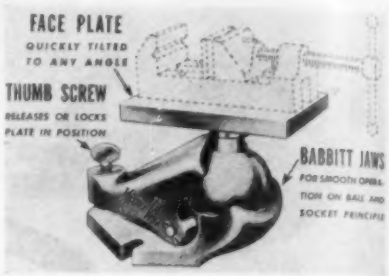
For metallic arc welding, with bare or coated electrodes, the new model also supplies uniform welding current for carbon arc welding.

The generator control or "job selector" assures accuracy of open circuit voltage and permits precise control of engine speed of from 1500 to 1150 rpm. for welding. In addition, this control may be used to manually reduce the engine speed to as low as 750 rpm. whenever it is necessary to stop welding at intervals of a few minutes. This feature not only permits adjustment of engine speed to fit the individual job, but also affords improved welding and keeps down fuel consumption and engine wear.

Weight of the unit as illustrated is approximately 1130 lb. Over-all length, 65¼ in.; width, 24 in.; height, 41⅛ in. Illustrated bulletin No. 312-C, describing this new welding unit, is available on request.

## METRO POSITIONER

The Metro Positioner is a recently developed tool for holding or clamping work during production operations, such as checking, milling, drilling, shaping, boring, welding, filing, pattern making and similar work.


FACE PLATE
QUICKLY TILTED TO ANY ANGLE
THUMB SCREW
RELEASES OR LOCKS PLATE IN POSITION
BABBITT JAWS
FOR SMOOTH OPERATION ON BALL AND SOCKET PRINCIPLE

Your present vise or fixture may be bolted or fastened to the "face plate" of the tool, which will then permit tilting your clamped work at any desired angle. The Metro Positioner operates on the ball and socket principal and is quickly released or locked in position by an easy turn of the conveniently located thumb screw. There are no graduations, the babbitt jaws give smooth operation and provide a rigid, nonslip hold.

Metro-Vise Co., with offices at 246 Stephenson Bldg., Detroit 2, Mich., now offers the Metro Positioner in two standard sizes: the 4-in. size measures 7¼ in. high, has an 8- x 11-in. plate, and weighs 58 lb.; the 3-in. size measures 5¾ in. high, has a 4- x 6-in. table, and weighs 30 lb. Literature sent on request.

## FLUXED WIRE SOLDER

A new type of fluxed wire solder, which contains flux in longitudinal grooves on the surface rather than in the conventional core, has just been placed on the market. According to the manufacturer, the product represents the first basic improvement in fluxed wire solder design since the introduction of this type of material a number of years ago.

The new material, called Fluxrite and put out by National Lead Co., 111 Broadway, New York City, is said to overcome completely an inherent disadvantage of regular cored solders which supply flux and solder to the surface simultaneously. Since the flux in the new product is outside rather than inside, it liquefies and flows onto the work before the solder melts. This insures thorough and complete fluxing and results in stronger and better solder joints.

In addition to prefluxing, the new solder also is said to guarantee an unbroken flow of flux. Interruptions in the flow sometimes occur with cored solders due to gaps or voids in the flux core. Since the new product has more than one flux-filled groove, there is naturally a continuous flow at all times.

An additional advantage claimed comes from the fact that the flux supply being outside the wire is always visible to the user and can be checked quickly and

# TRY THIS NEW FLUX....WELDALENE

MANUFACTURERS of coated welding rod are invited to investigate the possibilities of a new addition to Foote's comprehensive list of welding fluxes—known as Weldalene.

Weldalene is not "just another" flux. It fills, we believe, a long standing gap in fluxing materials. Among its properties, suggesting use in mild steel and stainless rods (A. C. or D. C.) are:

1. Unusual sintering characteristics. Weldalene begins to sinter at about 1920°F. But it does not deform below approximately 2140°F. Consequently, it is an active flux over a wide range of temperature, which suggests a means of controlling slag fluidity.

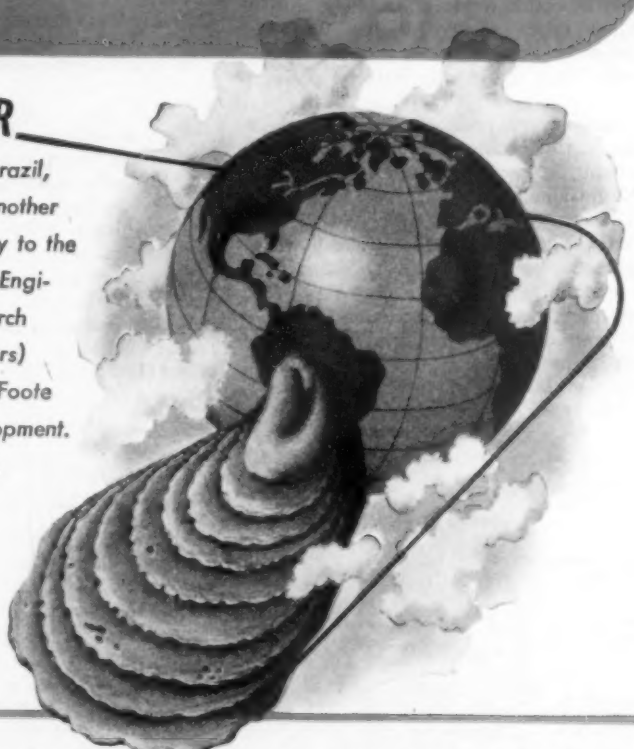
2. Weldalene is "silica hungry." Its ratio of alumina to silica is 1 to 2.5, indicating that Weldalene—by reacting with free silica—may reduce silica included in weld metal.

3. Weldalene contains a substantial percentage of potassium, assuring greater arc stabilization.

From recent studies and commercial applications in ceramics, it can be reported that Weldalene is an excellent vitrifying agent contributing to the glassy phase which combines other ingredients together more strongly. This property suggests that Weldalene might be used advantageously to increase the dry strength of coatings, eliminating to a degree unnecessary wastage of partly consumed electrodes. You are urged to write at once for a sample of Weldalene, analysis and prices. An inquiry will receive a prompt reply.

## THE WORLD IS OUR OYSTER

*Manganese from Cuba, Ilmenite from India, Rutile from Brazil, Celestite from Mexico . . . ores and minerals from many another Good Neighbor, from our Allies and from home find their way to the Foote Mineral Company on the heels of globe-trotting Foote Engineers. • Foote sees these products of the earth through research and processing, huddles with many industries (including yours) in their development. In addition to present definite uses of Foote products, there are probably many others now awaiting development. We urge you to let us work with you in your own research.*



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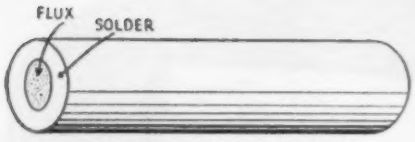
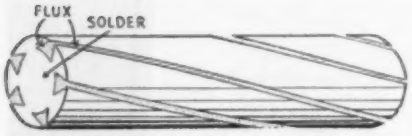



CONVENTIONAL FLUX-CORE WIRE SOLDER




NEW TYPE OF WIRE SOLDER WITH FLUX IN GROOVES

readily. Gaps or voids in ordinary-cored solders are not detectable until after soldering begins.

The new product, which contains a recently developed special flux, comes in the same diameters as regular-cored solder. It is available in two compositions designated as Red Stripe and Green Stripe. These designations refer to the color of the flux which has been specially dyed in each case for easy identification.

---

## "STORAGE BATTERY" WELDERS

What is believed to be the first practical d.-c. resistance welder using *storage batteries* as a source of welding current has been announced by Progressive Welder Co., 3050 E. Outer Drive, Detroit 12, Mich. The equipment is already in use, welding aluminum for aircraft assemblies.

Actually, the use of batteries as a source of "stored energy" for resistance welding involves no radical redesign of already available welding machines, since modified types of Progressive Welder machines or guns may be used in combination with the storage battery power unit.

It does make possible, however, the application of resistance welding even in aluminum, in localities where power supply limitations have prevented the use of other forms of stored energy welders. The only requirements are sufficient power to operate a battery charger. Compared with other forms of stored energy welders, furthermore, the use of batteries for the power source means a material reduction not only in initial cost of the welding installation but also in operating costs, particularly as to current consumption, maintenance costs and supervisory requirements.

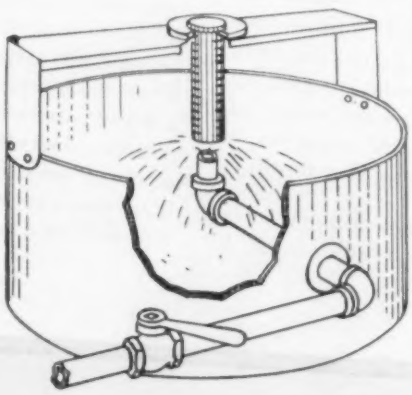
Other advantages of the use of storage batteries for welding reported by Progressive, include:

1. Elimination of inductive losses in the welding "loop" by use of direct current.
2. Elimination of reactance losses between power supply and electrodes.
3. Less critical adjustments to get consistently good welds.
4. Greater operating and maintenance simplicity.

---

## NEW FIXTURE FOR SIMPLIFYING THE JOMINY END QUENCH HARDENABILITY TEST

This new fixture, with its accessory tongs, for making easy the Jominy End Quench Hardenability Test for treatment for NE steels, has just been announced by the Claud S. Gordon Co., of Chicago.



**Cutaway View Showing Fixture for Making Jominy Hardenability Tests. The Test Specimen Is Shown Hanging in the Flange**

Such an appliance has been much needed ever since the American Iron and Steel Institute determined on the Jominy hardness test as the best and quickest method of determining the response of NE steels to heat treatment.

Great saving in time of testing is claimed for this new fixture.

Full information and data may be obtained by addressing the company's home office, 3000 S. Wallace St., Chicago 16, Ill.

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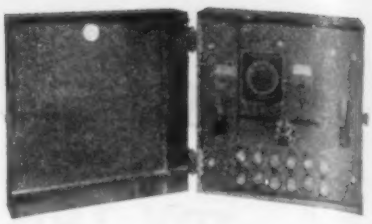
## CONTROL HOLDS RESISTANCE WELD CURRENT CONSTANT

A new current-regulating compensator for resistance welding machines has been announced by the electronic control section of the General Electric Co. The new compensator is specifically designed to facilitate consistent welds by holding the rms., or true heating value, of the weld current constant for any heat-control setting, without requiring continual manual adjustment.

After the predetermined heat-control setting for a particular job has been made



on the compensator, it requires no further adjustment. It will hold the welding current to a variation of $\pm 2\%$ under the same conditions which would cause the unregulated welding current to vary $\pm 20\%$.

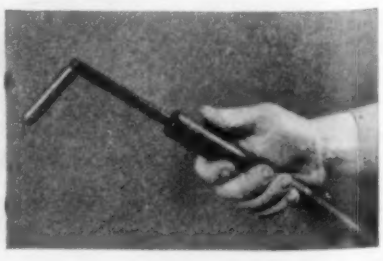
The compensator consists of an electronic control circuit which automatically retards or advances the firing point of the ignitron tubes used to control the welding current, thus holding the current constant regardless of line voltage changes or welding conditions. Housed in a sturdy steel enclosure, the compensator can be readily mounted on or near the welding machine. A desirable feature of the compensator is that it can be applied to most G-E resistance welding controls which incorporate the phase-shift method of heat control.

---

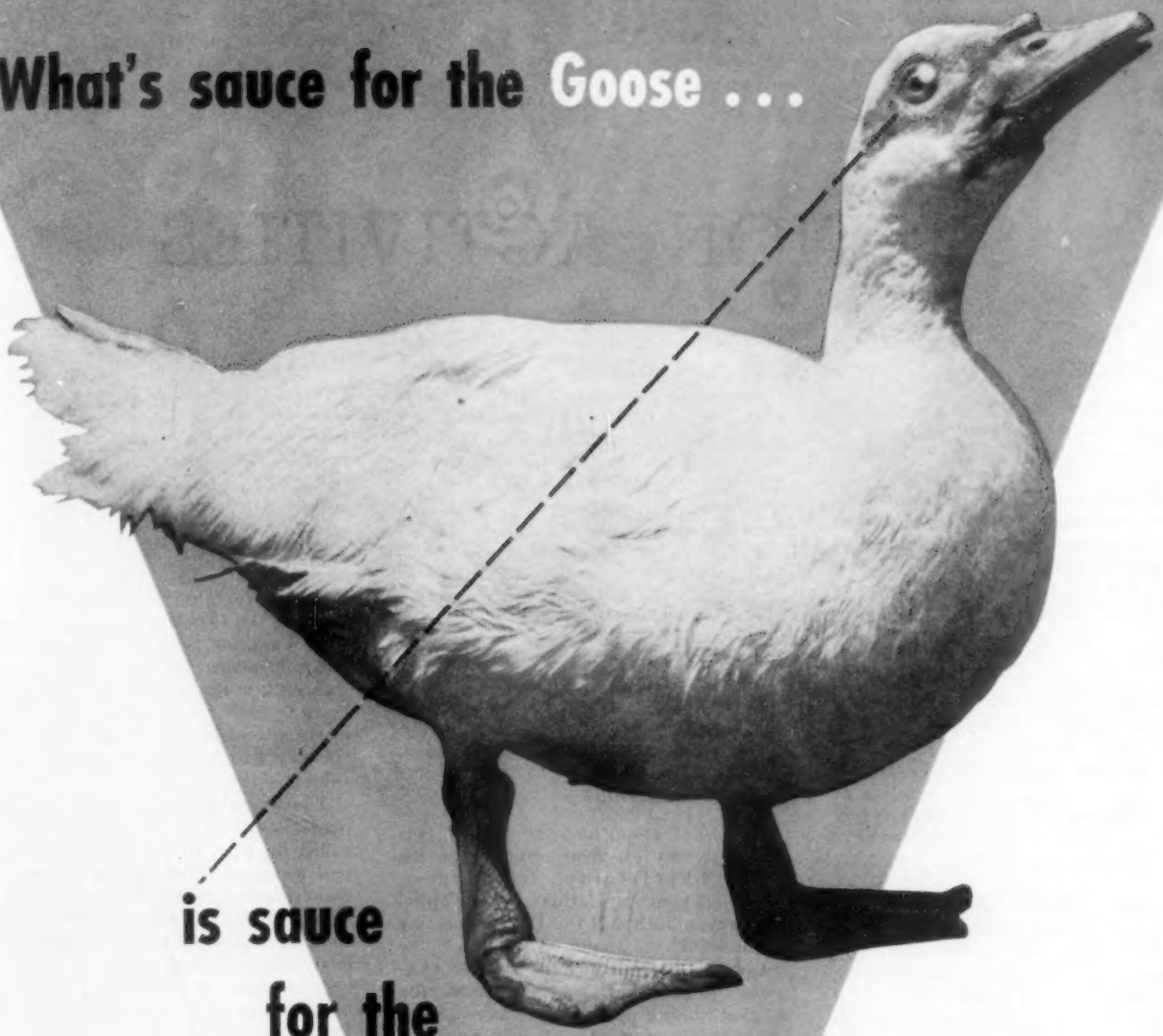
## HELIUM-SHIELDED ARC-WELDED ELECTRODE HOLDER

A new helium-shielded arc-welding electrode holder for manual operation has been announced by the Electric Welding Div. of the General Electric Co. The new holder, which may be used with either helium or argon gas, is specially designed for use in the welding of light metals, such as magnesium and its alloys, where precise heat control and protection from the oxidizing effect of the air are required. It can also be used in the welding of other hard-to-weld metals, such as aluminum and stainless steel.

The holder is light and consists of a comfortable Textolite handle, a steel gas nozzle, and a copper electrode clamp fitted with a tool steel spring-collet. The gas nozzle is designed to give maximum coverage with minimum gas consumption, and to avoid obstructing the operator's view of the arc. A fixed angle of 76° between the nozzle and the handle contributes to the balance and "feel" of the holder. The electrode clamp is constructed to hold a tungsten or a carbon electrode until all but a $\frac{3}{4}$-in. stub is consumed. The holder may be laid down without arcing, since the handle, gas nozzle and electrode clamp are fully insulated.



# What's sauce for the Goose . . .



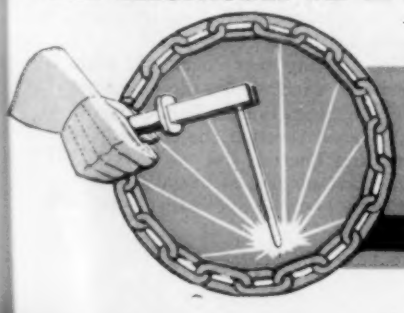
# is sauce for the Gander

And that applies to welding, too!

For production men agree that Electric Arc Welding —now contributing so essentially to America's wartime production—will play an equally vital part in the manufacturing processes of an approaching peacetime economy. This is just another reason why the **McKay** line of **Stainless, Alloy or Mild Steel Welding Electrodes** —now used nearly 100% for war—is being constantly improved and perfected in one of the nation's leading research institutes. When "Re-Conversion Day" comes, McKAY ELECTRODES will be ready and will embrace the improved metallurgical characteristics required by production-for-peace applications.

Now is the time to ask this 60 year old manufacturer to help you adapt electric arc welding to your present as *well* as to your future needs. McKAY engineers are at your service.

The McKAY line—including **McKay Commercial Chain** for every industrial, maritime or agricultural requirement; and **McKay Tire Chains,** too—will serve you well, both today and in countless applications tomorrow. Let's get better acquainted.



***General Sales Office: York, Penna.***

**THE McKAY COMPANY**
PITTSBURGH, PA.

WELDING ELECTRODES . . . COMMERCIAL CHAINS . . . TIRE CHAINS

A button for controlling the gas supply valve is located on the handle of the holder, where it is convenient to the operator's thumb. This button will remain in either the ON or OFF position without being held. It also operates the valve in intermediate positions, thus providing smooth, stepless control of the gas flow and enabling the operator to conserve helium when welding in a corner or a depression.

A feature of the new holder is the tapered friction joint between the electrode clamp assembly and the handle, which facilitates rapid change of electrode size without using tools or making threaded connections. Electrodes of various sizes may be left in their respective clamps and substitution made merely by removing one assembly from the handle and slipping on another.

# SECTION ACTIVITIES

## CHATTANOOGA

The Chattanooga Section's regular meeting was held on February 11th. G. N. Sieger, President and General Manager, S-M-S Corp., Detroit, spoke on present-day practices and future possibilities of resistance welding. A movie entitled "December 7th," showing action pictures of the attack and damage done, many scenes of which had not been previously shown in public, was of immense interest to all.

## CHICAGO

On January 21st A.W.S. District Vice-President George N. Sieger, President of S-M-S Corp., Detroit, spoke at the Chicago Section meeting held in the auditorium of the Peoples Gas Building at 122 S. Michigan Ave. Both the meeting and the premeeting dinner at Huyler's, 308 S. Michigan Ave. were very well attended.

Mr. Sieger's subject was "Resistance Welding—An Exact Science vs. Blacksmithing." This talk in his inimitable style was very well received by an appreciative audience. As a preliminary he also gave a pep talk on membership in his capacity as national chairman of the membership committee.

A good movie entitled "War Department Report," a special interest government pictorial dealing with the strength of our enemies and what it takes to crush them, was shown at 7:30 P.M. before the start of the regular program.

## CINCINNATI

The February meeting of the Cincinnati Section was held on the 8th at the Hotel Alms. W. W. Schultz, Welding Supervisor, Main Shop, L. & N. Railroad, Louisville, Ky., spoke on "Welding as Applied to the Railroad Industry."

## CLEVELAND

Mr. T. B. Jefferson, Editor of *The Welding Engineer*, spoke on "Welding in the Post-War World," at the February 9th meeting of the Chicago Section.

The effect of the welding process on the design of post-war products was discussed by Mr. Jefferson.

A graduate of the University of Kansas, Mr. Jefferson received his degree in mechanical engineering. Mr. Jefferson has been editor of *The Welding Engineer* for the past four years.

The Coffee Talk was by George C. A. Hantelman, lecturer and Secretary-Manager of the Cleveland Engineering Society. Mr. Hantelman spoke on "From Diplomatic Double Cross to White Cross." Mr. Hantelman's travels and five-year residence in Europe have given him first-hand knowledge of his subject.

## COLUMBUS

W. J. Conley, Acting Chairman, Department of Engineering, University of Rochester, was the guest speaker at the February 11th meeting of the Columbus Section. Professor Conley's discussion was on "The Metallurgy of the Weld and How Welding Affects the Parent Metal."

## DETROIT AND FLINT

The Flint group and the Detroit Section had very excellent meetings on the 3rd and 4th of February. The Flint meeting was held at the Herman Fischer Hotel at Frankenmuth and the Detroit meeting at the Rackham Memorial Building.

Colonel Scott B. Ritchie of the Ordnance Department, U. S. A. was the speaker at both meetings and gave a most interesting review of ordnance matériel, stressing the important part welding has played in its production, and finished by showing a series of slides depicting captured equipment and a moving picture of work done on this foreign equipment at our proving grounds.

Both meetings were outstanding.

## KANSAS CITY

The January meeting of the Kansas City Section of the AMERICAN WELDING SOCIETY was held Tuesday evening, January 10, 1944, at Fred Harvey's Pine Room.

The speaker of the evening was Edward B. White, Western Sales Manager, Eutectic Welding Alloys Co., on the subject, "Low Temperature Welding with Castolin Eutectic Alloys."

Mr. White's talk, supplemented with a number of slides was very interesting to the members and guests, since the materials and application were rather new and novel to the majority of the members, although some were present who have had enough experience with the alloys that they were able to ask some very interesting questions as well as give their experiences which assisted greatly in giving the not so experienced members a broader amount of information.

The Kansas City Section has been very fortunate in having such an interesting series of meetings this year and wishes that times were a little more normal so that more of the members and guests were able to join in these meetings and derive the great benefits possible out of them.

## LOS ANGELES

On January 20th, at Scully's Cafe, Los Angeles, the Los Angeles chapter, AMERICAN WELDING SOCIETY, showed that it still remembered how to dispose of a steak (believe it or not!) dinner, and then settled down to listen to an interesting discussion of the use of X-rays in examining welds. "X-Ray Examination of Welds" was the subject of the meeting.

The meeting opened under the chairmanship of Alex Maradudin, who first called for the introduction of guests and new members. During this ceremony occasion was taken to present a gold pin, on behalf of the Baltimore chapter, A.W.S., to Arthur Wynn. Mr. Wynn, newly transferred to the local chapter, is welding engineer at the U. S. Naval Dry Dock, Terminal Island, and is a past chairman of the Baltimore chapter.

Speakers of the evening were Robert Hiller, metallurgist (and member of the firm), and Dr. R. L. Ball, physicist, both of Triplett & Barton. Their subject was "The Application of the X-ray to the Examination of Welding." Mr. Hiller, however, contented himself with introducing Dr. Ball, a Canadian, and outlining a few interesting facts regarding his background.

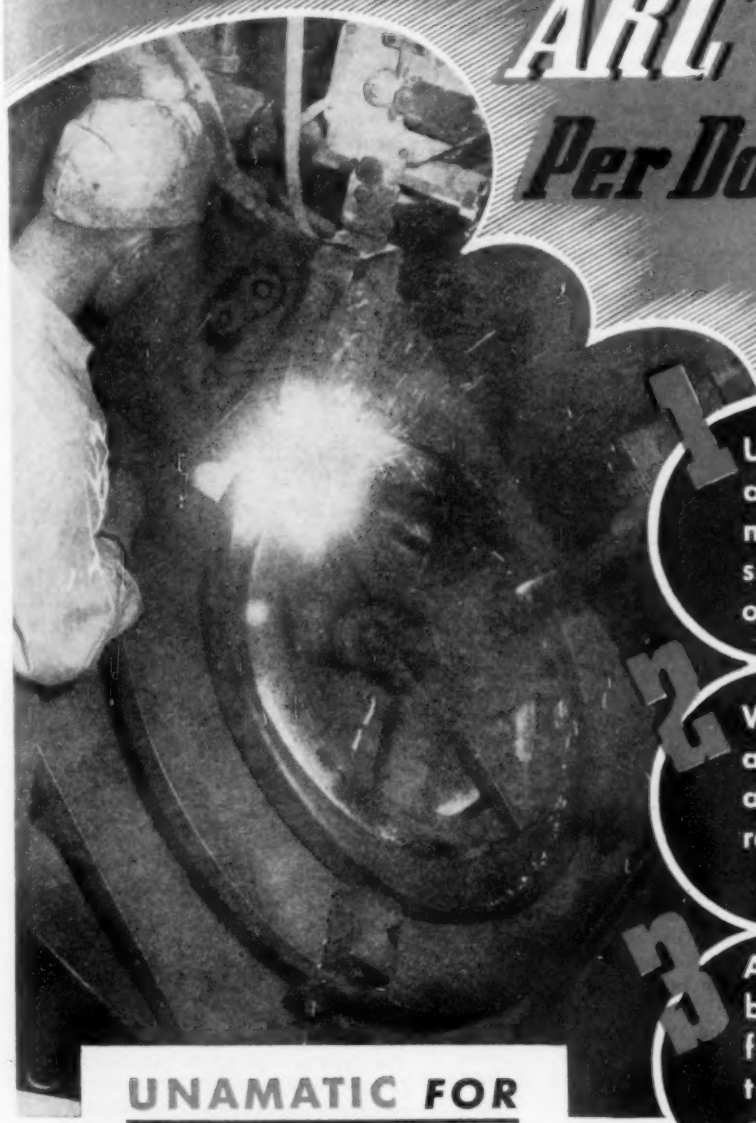
Dr. Ball delivered the actual address on the use of X-rays in metallurgy, illustrating his remarks from time to time with photographic slides. Explaining that while the radiologist in reality represented the purchaser. In other words, his job was to see that the weld met with all specifications agreed on.

In the general discussion that followed his talk, Dr. Bell brought out the point that X-rays revealed more in some cases than they did in others—owing to the fact that some metals and alloys offer more resistance to the rays than others.

The meeting was concluded with the showing of a technicolor motion picture on "Welding Stern Frames by Thermit Welding," loaned through the courtesy of the Metal and Thermit Co.

The next meeting was held on Thursday, February 17th, at the same place. The

# IN 3 WAYS YOU GET MORE ARC WELDING Per Dollar of COST



1 Unamatic Welding is 2 to 3 times as fast as manual operation. This means that in a given time the same number of welders can turn out 2 to 3 times as much work.

2 With Unamatic Welding there are no stub end losses, since wire and tape are in coil form. This results in a savings of 15-25% in materials used.

3 After operating procedure has been established, all operating functions are mechanically controlled. This assures uniform quality of deposited weld metal with Unamatic.

**UNAMATIC FOR FASTER... BETTER LOWER COST with AUTOMATIC WELDING**

*One of our field engineers will be glad to tell you how your company can get more arc welding per dollar of cost. Write or wire for information today—there's no obligation of course.*

CONTROLLED QUALITY **UNAMATIC WELDING** CONTINUOUS PRODUCTION

UNA WELDING INC. • 1615 COLLAMER AVE. • CLEVELAND, OHIO

general subject was "Methods for Quality Control in Aircraft Spot Welding." Mabel Rockwell, general director, research group engineers, Lockheed Aircraft Corp., Burbank, Calif., was a featured speaker. The technical aspects of the subject were discussed by Nathan C. Clark, senior research engineer, Lockheed Aircraft Corp.

As a special added feature of the February meeting there was a restricted motion picture, "Precision Naval Machinery for Victory." The showing of this film was confined to American citizens only.

## LOUISVILLE

Approximately 178 members and friends attended the dinner which preceded the regular monthly meeting on January 18th at the Seelbach Hotel. R. E. Fritsch, Vice-President of Tube Turns, Inc., acted as Master of Ceremonies.

The Honorable William H. Harrison, President of the Louisville Industrial Foundation and Ex-Mayor of Louisville, gave a short, entertaining talk which was followed by an address by David Arnott, President of the A. W. S

Mr. Arnott's talk on "Ship Welding" was very interesting, as well as instructive. The talk was devoted almost entirely to "failures" which have been experienced. Mr. Arnott stated that without *welded construction,* the enormous ship tonnage built by American Yards in 1943 would not have been possible.

Following his talk, Mr. Arnott very graciously answered the many questions asked by the audience.

## MARYLAND

The January meeting of the Maryland Section was held at the Engineers' Club in Baltimore, on the 21st. Approximately 80 members and guests attended.

A very interesting talk was given by LaMotte Grover, Welding Engineer of the Air Reduction Sales Co. Mr. Grover's subject was "Procedure Control and Detail of Design for Welded Ships and Other Large Welded Structures."

## MILWAUKEE

The Welding Address at the January 28th meeting of the Milwaukee Section was given by H. S. Card of the Formed Steel Tube Institute, who spoke on "Formed Steel Tubing in Welded Construction." Mr. Card's talk included a movie on the process of manufacturing of welded tubing and was also illustrated by slides.

## NEW JERSEY

Following dinner at the Essex House, Newark, the regular monthly meeting was held on January 18th. Ninety-two members and guests attended the meeting. R. J. Pass of Tempil Corp. demonstrated temperature indicators by use of Tempil sticks. D. A. Watson, Metallizing Engineering Co., exhibited spraying guns and several samples of smaller applications of metal spraying.

## NEW JERSEY AND NEW YORK

One of the most successful welding meetings ever conducted in the New York area was held on Friday, January 14th, at the Hotel Commodore in conjunction with the War Production Board Conference.

Approximately 20 technical societies cooperated to make the conference an outstanding success. Attendance at dinner held in the grand ballroom was approximately 1500. Eddie Rickenbacker, President of Eastern Air Lines, was the principal speaker at dinner. After outlining his recent trip to the fighting fronts all over the world, he made a special plea for understanding and cooperation with our ally Russia.

At the conclusion of dinner, the audience broke up into smaller groups for the various panel sections. The Welding Panel was conducted under the auspices of the New York and New Jersey Sections of the AMERICAN WELDING SOCIETY and the New York Section of the Society of Naval Architects and Marine Engineers. About 450 members and guests attended the Welding Panel. The purpose of the panel was to aid industries in the New York area in their welding, cutting and allied process problems. It consisted of a question and answer session in which questions were received from the floor from the audience regarding problems and answers given by a capable panel of welding and cutting experts from key industries in the Metropolitan area.

David Arnott, National President of the AMERICAN WELDING SOCIETY, member of the Council of the Society of Naval Architects and Marine Engineers, and Vice-President and Chief Surveyor of the American Bureau of Shipping, presided.

Mr. Arnott introduced the Society's Section Chairmen as well as the panel members, and outlined the procedure for conducting the meeting.

William Spraragen, Executive Secretary of the Welding Research Council and Editor of THE WELDING JOURNAL, presided as Vice-Chairman and addressed the meeting at large on "Welding at War."

Homer R. Morrison, Union Carbide and Carbon Corp., led in the discussion. Members of the Panel were as follows: Aircraft Welding, H. O. Klinke, Republic Aviation Corp.; Arc Welding, R. E. Bedworth, Westinghouse Electric & Manufacturing Co.; Flame Cutting, H. E. Rockefeller, The Linde Air Products Co.; Low Temperature Brazing, A. M. Setapen, Handy & Harman; Metallurgical Aspects, O. H. Henry, Brooklyn Polytechnic Institute; Oxyacetylene Welding, A. N. Kugler, Air Reduction Sales Co.; Pressure Vessel Welding, K. L. Walker, Foster Wheeler Corp.; Resistance Welding, R. S. Donald, Thomson-Gibb Electric Welding Co.; Shipbuilding, H. W. Northcutt, Bethlehem Shipbuilding Division.

## NEW YORK

The New York Section held its regular monthly meeting on Monday, February 7th, at the Engineering Societies Building. Members of the Society of Naval Architects and Marine Engineers were invited to attend this meeting, the subject of which was "Shipbuilding." Technical Chairman for the evening was J. L. Wilson, Assistant Chief Surveyor, American Bureau of Shipping, New York.

Speaker for the evening was George F. Wolfe, Chief Engineer, Engineering Works Division, Dravo Corp., Wilmington, Del. Mr. Wolfe discussed the importance of welding in the construction of many types of small and medium-sized watercraft. He particularly emphasized the assembly line production method which his company has developed for the construction of welding steel floating equipment. Mr. Wolfe's presentation was illustrated with a large number of lantern slides which started with the Dravo Corp.'s developments during the 1937 period and continued to the present-day enlarged facilities necessary to meet the demands imposed by war.

At the conclusion of Mr. Wolfe's talk, the United States Navy motion picture "Life and Death of the Hornet" was shown. The evening opened with a half-hour question and answer period conducted by H. O. Klinke, Republic Aviation Corp., Farmingdale, L. I.

## NORTHERN NEW YORK

About 80 members and guests attended the January 27th meeting of the Northern New York Section held at Hotel Van Curler, Schenectady. Dinner preceded the meeting. T. B. Jefferson, Editor of *The Welding Engineer*, spoke on "Welding in the Postwar World." Mr. Jefferson started with present business conditions and narrowed down through labor, equipment, material, etc., to welding processes.

## NORTHWEST

F. C. Hasse, General Manager of The Oxweld Railroad Service Co., Chicago, presented an illustrated talk on "Railroad Welding" at the January 18th meeting held at Coffman Memorial Union, University of Minnesota.

## OKLAHOMA CITY

The February meeting of the Oklahoma City Section was held on the 10th, at the Biltmore Hotel. The speaker of that date was Leon C. Bibber, Welding Engineer, Carnegie-Illinois Steel Corp., Pittsburgh, Pa. He presented in an excellent manner his subject "The Elements of Welded Design." This is quite a large field and also an extremely interesting field to designers originally schooled for riveted construction. Mr. Bibber covered quite thoroughly the ground which is vitally needed to connect riveted design with welded design. He showed and discussed many of the common design errors which are made in attempting to apply welding to riveted design.

The use of a Question Box was inaugurated with this meeting, and it is believed that in the future it will prove to be of much benefit to the group as a whole, as well as clearing up some question which has been troublesome to someone.

In the absence of M. G. Wicker, Local Chairman, who was out of town on business, Howard Simms, Vice-Chairman, presided. The meeting was well attended in spite of adverse weather conditions.

# Hours for repair SAVE Weeks for replacement

## Anaconda "997" repair weld saves sheet production at National Lead Company

A CRACKED SPOKE in one of the main drive gears of the 97" reversing sheet rolling mill at the National Lead Company Plant in Cleveland, Ohio threatened vital war production. It looked like weeks of downtime while a replacement gear made the tedious journey through pattern shop, foundry and machine shop.

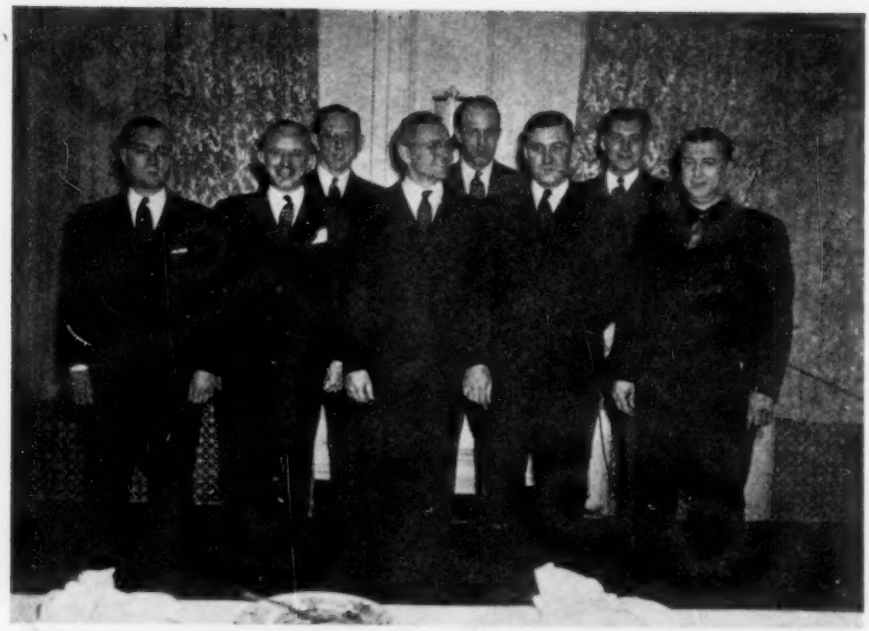
But, in a matter of hours the mill was rolling again. A repair weld was made by the Neal Welding Company of Cleveland with Anaconda 997 Low-Fuming Rod, and without dismantling the machine.

Thanks to Anaconda Welding Rods and Tobin Bronze*, "Don't scrap it . . . *weld* it!" has become a war production slogan in industrial plants from coast to coast. Remember that before you call the junk man. 4487

*Reg. U. S. Pat. Off.

**THE AMERICAN BRASS COMPANY**
*Subsidiary of Anaconda Copper Mining Company*
General Offices: Waterbury 88, Connecticut
*In Canada:* Anaconda American Brass Ltd., New Toronto, Ont.

ANACONDA *Anaconda Welding Rods*



**Some of the New Officers, Peoria Section**

Front Row, Left to Right. Kenneth Jackson, Larry O'Day, Walter J. Brooking, Clifford Wimmer, and Alfred A. Wald. Back Row, Left to Right. Herman Moyer, Harold Baldwin and Lyle Bibb.

## PEORIA

On Wednesday, January 19th, the Peoria Section held their annual banquet and installation of new officers. The Section also had the privilege of hearing R. G. LeTourneau, President of R. G. LeTourneau, Inc. His talk was on welding in the past and present, and on his personal viewpoints of the future of welding, which brought out numerous questions from the 80 members and guests present.

The officers and directors for 1944 are as follows: *Chairman*, Walter J. Brooking, R. G. LeTourneau, Inc.; *Vice-Chairman*, Alfred A. Wald, Caterpillar Tractor Co.; *Secretary*, Harold Baldwin, R. G. LeTourneau, Inc.; *Treasurer*, John Hanley, A. Lucas & Sons.

Executive Committee to serve for 2 years: Kenneth Jackson, Clifford Wimmer and Lyle Bibb.

Directors for 1 year: L. W. O'Day, Herman Moyer and Edwin Schmidt.

On Wednesday, February 2nd, Wm. J. Conley, Consulting Engineer, The Lincoln Electric Co., addressed the meeting on "Weld Joint Design, Selection and Preparation." He had a fine selection of slides and also illustrated joint behavior under stress with a polarized light projector. Approximately 100 members and guests were present.

## PHILADELPHIA

At the January meeting of the Philadelphia Section, the members enjoyed an interesting talk on "Thermit Welding" by J. A. Deppeler, Chief Engineer of the Metal & Thermit Corp. Mr. Deppeler accompanied his talk with the showing of two color motion pictures descriptive of the Thermit Welding Process.

The 200 members present were honored by a visit from our new District Vice-President, H. W. Lawson, Chairman of the Lehigh Valley Chapter. Mr. Lawson was also our guest at the Executive Committee meeting and dinner preceding our regular meeting.

The Philadelphia Section is cooperating with the Philadelphia Chapter of the American Society for Metals in sponsoring a course in the Metallurgy of Welding, given at Temple University, which started on February 28, 1944. The course is using Henry & Claussen's *Metallurgy of Welding* as a text, with prominent metallurgists assigned to give lectures on the various subjects covered by it. These lectures are being supplemented by a 15-week laboratory course covering everything from the use of the metallurgic microscope down to practical welding applications. The course is designed to accommodate at least 100 students and a price of $25 is charged.

On Friday, February 4th, the fourth in a series of six panel discussions was held at the Engineers' Club. A. B. House, O. C. Frederick and John Fetcher discussed various phases of Resistance Welding. Mr. House covered aluminum welding, Mr. Frederick, 1/8-in. and heavier mild steel, and Mr. Fetcher, stainless steel. Each man's talk was limited to about five minutes, so as to allow ample time for discussion. The room was so crowded that some of the men had to stand out in the hallway, and with the meeting lasting over two hours, we are sure that everyone went home much better informed than he was when he came. These panel discussions are becoming so popular that it will soon be necessary for us to make arrangements for larger quarters.

## PITTSBURGH

Nearly 150 members and guests attended the regular meeting of the Pittsburgh Section, January 19th, to hear La-Motte Grover, Welding Engineer, Air Reduction Sales Co. of New York, present a discussion on "Procedure Control and Details of Design for Welded Ships and Other Large Welded Structures."

The discussion covered methods of control in production and details of design for ships, etc., to insure sound welds and to avoid serious shrinkage strains and distortion.

While slides taken from shipbuilding were used to illustrate his discussion it was brought out that the fundamental principles apply generally to all welded structures. In addition to details of design, Mr. Grover's talk covered materials, general organization of the work, supervision, fabrication, welding procedure and sequence, flame straightening, etc.

Following the presentation the meeting was opened for discussion.

## PUGET SOUND

The January meeting of the Puget Sound Section of the AMERICAN WELDING SOCIETY was held at the Gowman Hotel, January 26th. The meeting was well attended and was one of the most enthusiastic meetings we have had this season. G. A. MacGillivray, West Coast Sales Manager of Eutectic Welding Alloys Co., gave a slide lecture on low-temperature alloy welding. The talk raised many questions and created considerable open forum discussion.

## ROCHESTER

On February 3rd the Rochester Section held a meeting at the University of Rochester. A. C. Weigel, Combustion Engineering Co., spoke on "Manufacture of High Pressure Boiler Drums." Mr. Weigel's talk was very well received by the 50 members and guests present and a lively discussion followed.

## SAN FRANCISCO

There were approximately 100 members and guests present at the January 28th meeting held at the El Jardin Restaurant. Among the honored guests at this meeting were Jim Gowing, Western District Vice-President, Allan Renton of the Hawaiian Gas Products Co. of Honolulu, and the newest Sustaining Member, Leo Berner, representing the Joshua Hendy Iron Works.

A motion picture entitled "The Life and Death of the Hornet," depicting the heroic career of the aircraft carrier, was most interesting.

William Aldrich, District Manager of the Metal & Thermit Corp., addressed the group and showed two motion pictures illustrating thermit welding on stern castings of liberty vessels and railroad tracks.

Mr. Aldrich's talk was very interesting and the films gave an insight to thermit welding heretofore unknown to many. The members and guests were very pleased with the program.

## SYRACUSE

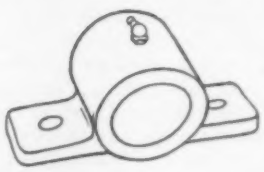
The February meeting held on the 10th was addressed by R. F. Helmkamp of

# "OVERCOMING DIFFICULTIES AND DANGERS"—he says

**Look, Tojo:** How having *Recourse to Arc Welding*, the production of war tools became *very simplified* for us . . . while their effect really made your position "VERY COMPLICATED."

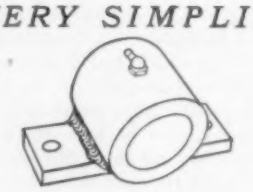
And think how in postwar they will make competition "Very Complicated" for a great many standpatters in production techniques.

## VERY COMPLICATED, PLEASE



Drum shaft bearing . . .
Make pattern . . .
Mould . . .
Sand-blast . . .
(Cost in rough, $1.05)
Bore . . . Machine . . .
Drill holes.

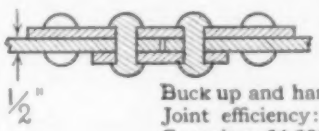
## *VERY SIMPLIFIED, THANKS*



Cut strap and drill holes . .
Saw piece of tubing . . .
Arc weld into unit. . . .
Total cost $0.50.

## VERY COMPLICATED, PLEASE

Structural joint requiring ½" plates . . .
Layout plates and straps accurately . . .
Drill holes accurately . . .
Put red-hot rivet in each hole . . .

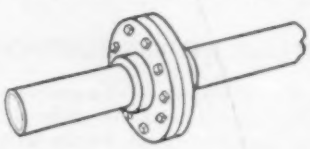



Buck up and hammer down rivet heads . . .
Joint efficiency: 81.3%
Capacity: 24,390 lbs. per inch.

## *VERY SIMPLIFIED, THANKS*

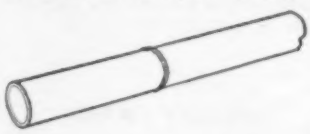
Only 7/16" plates required . . .
Bevel edge of plates . . .
Arc weld plates . . .
Joint efficiency: 100%
Capacity: 26,250 lbs. per inch.

## VERY COMPLICATED, PLEASE



Connection in 10" steam pipe line . . .
Cut and thread ends of pipe . . .
Assemble with 2 flanges, gasket and set of bolts.
Joint requires maintenance.

## *VERY SIMPLIFIED, THANKS*

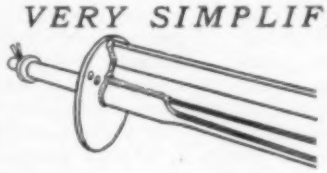


Arc weld bevelled-end pipe . . .
A permanent, leak-proof joint.

## VERY COMPLICATED, PLEASE

Axle for hay rake . . .
Make dies . . .
Forge parts . . .
Machine to fit . . .
Thread truss rod . . .
Assemble by bolting . . .
100% cost for loose-working assembly.

## *VERY SIMPLIFIED, THANKS*



Cut angle, strap, bar and plate . . .
Arc weld into one unit . . .
70% cost for permanent assembly.

**THE LINCOLN ELECTRIC COMPANY · CLEVELAND 1, OHIO**

the Air Reduction Sales Co., who spoke on the subject of flame cutting.

The April 13th meeting will be patterned after an "Information Please" program.

May 11th will be the last regular meeting of the year and will be a social affair and an opportunity to elect officers and make arrangements for the fall program.

## TOLEDO

The Toledo Section met on Tuesday, January 18th, in the Casino Room of the Hotel Secor. Commander Richard D. Schmidtman, Coast Guard Resident Inspector at Toledo Shipbuilding Co., read a paper on "Coast Guard Inspection of Welding in Shipbuilding." It graphically described the aims of the Coast Guard in ship inspection.

Milton Forman, Welding Engineer at Toledo Shipbuilding Co., read a paper on "Welding Sequence in Shipbuilding." His paper illustrated the application of a proper welding sequence to the Coast Guard Ice Breaker *Mackinaw* with $1^5/_8$-in. shell plating.

On Tuesday, December 21st, at the Hotel Secor, an interesting program was arranged which included the following: Lt. Raphael S. Florek gave an interesting talk on "Ordnance Inspection and Conversion and Substitution." After this talk, a very interesting War Department film was shown on "Conversion and Substitution."

## WASHINGTON, D. C.

The January meeting of the Washington Section of the A.W.S. was addressed by John H. Deppeler, past national president and one of the founders of the Welding Society. C. E. Jackson, who was recently elected vice-chairman of the D. C. chapter to succeed B. J. Brugge, acted as chairman of the meeting.

Mr. Deppeler, chief engineer of Metal & Thermit Corp., discussed the chemistry and mechanics of thermit welding and with the aid of slides accented many of the pertinent facts. The chemical reactions involved in reducing oxides of iron, manganese, chromium, tungsten, vanadium, titanium, nickel, molybdenum, silicon, boron and cobalt in the crucible, the lining of the crucible, molding, properties of thermit welds and applications of the art were some of the high points of the speakers' talk.

Mr. Deppeler showed the complete thermit welding process by the use of color films. One, "Thermit Welding of Stern Frames of Cargo Ships," pictured the joining of large cast steel sections to make a solid one-piece weld-cast frame. During the process the steps were shown in detail; flame cutting the edges to be welded, fitting up, construction of the wax pattern, building the mold, drying out, setting up the crucible, melting the thermit, casting the steel, and finally, after knocking off the mold, trimming up the weld. The finished stern frame was then shown being set in place.

The second color film showed the thermit welding of rail track to form a continuous track through the Moffat Tunnel of the Denver Rio Grande Railroad. The engths of rail were welded outside the tunnel in 1000-ft. lengths and pulled into the tunnel for final assembling. The long lengths were welded together the same way the short pieces were. The advantages of thermit welding were obvious from the films. The joints were shown to be stronger than the cast parts joined, skilled labor was not necessary, the welded regions were free of internal strains and the process is relatively simple.

Another film of unusual interest "Baptism of Fire" was presented at the meeting. This picture made by the Army Signal Corps showed three particular men and their company sent into combat for their first taste of actual battle. The horrors of the fight were brutally unreeled and the audience was tense with deep interest. A jolly get-together followed the meeting with the serving of refreshments to guests and members.

## WESTERN MASSACHUSETTS

The January meeting was held in the Holyoke Trade School at 8:00 P.M. on Monday, January 24, 1944. In opening the meeting the chairman, Mr. Emery, greeted 53 members and guests in attendance.

Announcement was made of a visit from F. C. Fyke, District chairman of the New York-New England District on February 28th, the date of our February meeting. In an appeal to boost membership thereby making the section a better functioning group, it was noted that five new memberships were received during this meeting.

Continuing to the technical session, Mr. Emery introduced W. J. Conley, consulting engineer to The Lincoln Electric Co. of Cleveland, Ohio. Illustrating his talk with numerous slides, Mr. Conley gave a 65-min. dissertation on the "Use and Application of the Shielded Arc." Comparing the manual arc to a precision tool, Mr. Conley discussed the important aspects of getting the most out of the shielded arc. With stress on the fact that the postwar industry will challenge the ingenuity of welding technicians even to a greater extent than realized to date, Mr. Conley showed several facts and figures where welding has and will surpass other methods of fabrication.

A lively question period followed the talk, after which Mr. Emery expressed the appreciation of the section to Mr. Conley for this fine talk.

As an added feature the talking movie "To Each Other" was shown through the courtesy of the United States Steel Co. With some extremely interesting views of modern applications of steel to the war effort, the picture was an enjoyable addition to an already successful evening.

## WICHITA

The January meeting of AMERICAN WELDING SOCIETY, was held January 6th at the Allis Hotel. Twelve members and guests were present for the informal dinner at 6 P.M. The business meeting began at 8:00 P.M. in the Empire Room of the Allis Hotel.

The speaker was G. N. Sieger of the S-M-S Corp., Detroit. He gave a very entertaining and interesting lecture and sketch on the principles of resistance welding.

Mr. Sieger also explained the purposes of the AMERICAN WELDING SOCIETY and what they expect to accomplish. He is Chairman of the Membership Advisory Committee and is well qualified to talk on this subject.

About 80 members and guests were present.

## YORK-CENTRAL PENNSYLVANIA

The January 12th meeting held at the Engineering Society of York Building, had as guest speaker, J. H. Humberstone, who spoke on "Arc Welding Electrodes – Types, Specifications and Uses."

The February meeting held on the 9th was addressed by A. N. Kugler of the Air Reduction Sales Co., who spoke on "Jigs and Welding Fixtures."

## YOUNGSTOWN

The January meeting of the Youngstown Section was held on the 12th in the Odd Fellows Hall, with an attendance of 160 members and guests. The speaker, Hugo W. Hiemke, Engineer, of the Bureau of Ships, gave a very interesting talk on the "Inspection of Welding of Ships." During the talk there was a form of questions, answers and general discussion on the general procedure, methods and variations on marine welding of which there was a very active participation by a good portion of the attending members.

The Youngstown Section are using at each meeting several short film sections of current interest relating either to war action or general production in connection with the war effort.

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## RESISTANCE WELDING EQUIPMENT

The War Production Board announced Feb. 16th that Limitation Order L-298 had been amended to require the filing of WPB-1319 as the authorized form for the delivery of resistance welding equipment. Formerly WPB Form 2752 had to be filed to obtain authorization for delivery of this type of equipment.

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## MALLORY AWARD

P. R. Mallory & Co., Inc., Indianapolis, Ind., manufacturers of electronic and metallurgical products, has been granted a fourth renewal of the Army-Navy "E" Production Award for meritorious services on the production front. Mallory was among the first plants to receive the original "E" and the award of four stars testifies to the maintenance of the company's outstanding production record.

Addition of the coveted fourth star to the Mallory Army-Navy "E" flag was accompanied by the following citation from Admiral C. C. Bloch, Chairman of the Navy Board for Production Awards:

"The men and women of your plant have continued to maintain the high standards they set for themselves when they were originally awarded the Army-Navy 'E'. They may well be proud of their achievement.

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# List of New Members

January 1 to January 31, 1944

### BOSTON

**Lynch, Paul F.** (C), 52 Bartlett Ave., Edgewood 5, R. I.

### CANADA

**Williams, Leonard W.** (B), Inspection Board of United Kingdom and Canada, 306 Pigott Bldg., Hamilton, Ont., Canada.

### CHICAGO

**Andree, Nicholas A.** (B), 6771 Talcott Rd., Chicago 31, Ill.
**Jonak, John H.** (B), 1149 N. Massoit Ave., Chicago, Ill.

### CANTON

**Minser, James H.** (C), 412 Corona Ave., Dayton 9, Ohio.
**Ratliff, Orval S.** (C), 336 West 4th St., Ashland, Ohio.

### CLEVELAND

**Fairbanks, J. M.** (B), c/o Euclid Road Machinery Co., 1361 Chardon Rd., Cleveland, Ohio.
**Pope, C. Carver** (B), Glascote Products, Inc., 20900 St. Clair Ave., Euclid P. O., Cleveland, Ohio.

### COLUMBUS

**De Lille, W. C.** (B), 772 Marion Rd., Columbus 7, Ohio.
**Holt, James D.** (B), 857 King Ave., Columbus 8, Ohio.
**Hull, D. J.** (C), 1472 Brentnell Ave., Columbus 3, Ohio.
**Lane, Norman** (B), Industrial Welding Co., 114½ Second St., Marietta, Ohio.
**Sonner, Glen E.** (C), 12183 West Toun St., Columbus, Ohio.
**Snyder, Wm. F.** (B), 351 W. 3rd Ave., Columbus 1, Ohio.

### DETROIT

**Benedict, Chester J.** (C), 564 Spencer, Ferndale 20, Mich.
**Bisel, Glenn E.** (C), 18659 Mansfield, Detroit 19, Mich.
**Blum, Harry M.** (B), 1976 Brighton Ave., Detroit, Mich.
**Bortman, Walter J.** (B), Budd Wheel Co., 12141 Charlevoix Ave., Detroit 14, Mich.
**Dittrich, Donald A.** (B), Silver Lake, South Lyon, Mich.
**Dyer, Daniel P., Jr.**(B), Budd Wheel Co., 12141 Charlevoix Ave., Detroit 14, Mich.
**Elgert, Henry** (B), 3130 S. Greyfriars Ave., Detroit 25, Mich.
**Ellis, Fred M.** (B), 17140 Shaftsbury Rd., Detroit 19, Mich.
**Eminger, Richard** (C), 20525 Andover, Detroit 3, Mich.
**Fleming, Jack W.** (B), 13966 Mendata Ave., Detroit 4, Mich.
**Fowler, Edward P.** (B), 4050 Larchmont, Detroit 4, Mich.
**Gardynik, Martin, Jr.** (B), 9582 Longacre, Detroit 27, Mich.
**Judd, Haney L.** (B), 12724 Freud, Detroit, Mich.
**King, Arnold V.** (B), 5684 St. Hedwig, Detroit 10, Mich.
**King, Jack C.** (C), 8200 Epworth, Apt. 24, Detroit, Mich.
**Kline, Kenneth W.** (B), 7550 Huron, R. R. 4, Dearborn, Mich.
**Mitchell, Coy F.** (B), 4846 Williams, Detroit, Mich.
**Moore, W. N.** (B), Westinghouse Elec. & Mfg. Co., 5757 Trumbull Ave., Detroit 8, Mich.
**Oberly, John F.** (C), 8251 Northlawn, Detroit 4, Mich.
**Picha, Thomas G.** (B), 27640 Joy Rd., Garden City, Mich.
**Pomorski, Leo J., Jr.** (B), 3382 E. Palmer, Detroit 11, Mich.
**Redford, James J.** (C), 5665 Calhoun, Dearborn, Mich.
**Rolando, Joseph** (B), 18633 Prospect Ave., Melvindale, Mich.
**Schroeder, Harold I.** (C), 1431 Cleveland, Lincoln Park, Mich.
**Seymour, Richard** (C), R. F. D. 3, Utica, Mich.
**Shwayder, Ben H.** (B), Shwayder Bros. Inc., 4270 High St., Ecorse, Detroit 18, Mich.
**Shwayder, King D.** (B), Shwayder Bros. Inc., 4270 High St., Ecorse, Detroit 18, Mich.
**Sinkiewicz, Anthony** (B), 3361 South Beatrice, Detroit 25, Mich.
**Staggs, Russell W.** (B), 8551 Westfield, Detroit 4, Mich.
**Utley, James E.** (B), 1742 Trumbull Ave., Detroit, Mich.
**Vinet, George** (B), Owens Welding Co., 309 Orleans, Detroit, Mich.
**Ward, Hubert** (B), 9000 Evergreen, Detroit, Mich.
**Watts, Robert C.** (B), 1555 Ruffner, Birmingham, Mich.
**Wheeler, Roscoe M.** (C), 2115 Mountain Ave., Flint, Mich.
**Williams, Fred E.** (C), Buick Motor Div., Wks. Engrg., Dept. 25, Flint, Mich.
**Williams, Samuel** (B), 12075 Wilshire, Detroit 5, Mich.

### INDIANA

**Jenkins, Roy L.** (C), 270 N. Bellview Pl., Indianapolis, Ind.
**Mohr, Lloyd K.** (C), 1426 Sheffield St., Indianapolis, Ind.
**Wood, Arthur F.** (B), 3719 Hillside Ave., Indianapolis 1, Ind.

### LOS ANGELES

**Bechtle, Joseph F.** (B), Standard Steel Corp., 5001 S. Boyle Ave., Los Angeles, Calif.
**Bickley, Sam** (C), Lincoln Electric Co., 812 Mateo St., Los Angeles, Calif.
**Carr, E. M.** (C), 1591 Cardiff Ave., Los Angeles 36, Calif.
**Delaney, Bruce** (C), 350 Third St., Laguna Beach, Calif.
**Dixon, Walter J.** (B), 649 South Burnside, Los Angeles 35, Calif.
**Evans, James K.** (C), 24A Corona, Long Beach, Calif.
**Fleming, Roy J.** (C), 724 Myrtle Ave., Inglewood, Calif.
**Humbert, Chester W.** (B), 2517 Curtis Ave., Redondo, Calif.
**Johnson, George A.** (C), Western Pipe & Steel Co., 5717 Santa Fe Ave., Vernon, Calif.
**Kirkendall, E. M.** (B), Tech.-Welding, 52 E. Palm, Burbank, Calif.
**Livingston, Willard E.** (C), 2128 Withrow Ct., Banning Homes, San Pedro, Calif.
**McCrillis, Lieut. J. A.** (C), c/o Western Pipe & Steel Co., 5717 Santa Fe Ave., Los Angeles 11, Calif.
**Miller, Clay W.** (C), Signal Hill School of Welding, 1207 E. Hill St., Long Beach, Calif.
**Mitchell, Joseph E.** (C), 123 West 118th Pl., Los Angeles, Calif.
**Ritko, Harold L.** (C), 1836½ Dome Ct., San Pedro, Calif.
**Silverman, Woodrow** (B), Emsco Derrick & Equip. Co., c/o Structural Shop, 6811 South Alemeda St., Los Angeles, Calif.
**Smith, Frank B.** (C), 4140 Arlington Ave., Los Angeles 43, Calif.
**Smith, William R.** (C), Lincoln Electric Co., 812 Mateo St., Los Angeles 21, Calif.
**Taylor, Roland H.** (B), Industrial Equipment Co., 4441 Santa Fe Ave., Los Angeles, Calif.

### LEHIGH VALLEY

**Henning, Ammon** (C), Taylor-Wharton Iron & Steel Co., Easton, Pa.
**Lord, B. Brevard** (B), 507 Penn Ave., Wernersville, Pa.

### LOUISVILLE

**Haun, George F.** (C), Box 25, West Point, Ky.
**Lloyd, Vivian A.** (C), 2324 So. 6th St., Louisville, Ky.
**Richert, L. G.** (C), 5021 So. 3rd St., Louisville, Ky.
**Ulrich, AV/MS. 2nd CL. James L.** (C), Navy 720, F. P. O. New York, N. Y.

### MARYLAND

**Adams, Edward** (C), 5574 Ashbourne Rd., Halethorpe, Md.
**Gore, J. W.** (B), 3707 Woodbine Ave., Baltimore, Md.
**Justis, Hugh D.** (C), 2785 The Alamada, Baltimore 18, Md.
**Machen, Raymond S.** (C), 1400 Eastern Ave., Baltimore 31, Md.
**Small, Joseph W., 3rd** (B), American Bridge Co., 601 Mercantile Trust Bldg., Baltimore 2, Md.
**Stratton, Wm. C.** (C), Creek Beeches, Old Powder Mill Rd., Hyottsville, Md.

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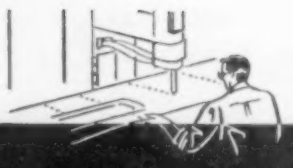

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| PMCO.1-11 PRESS TYPE | 60 | 24" | .020-.125 | 180 - .032 | 2600 | 1 | Monel Metals, Mild, corrosion-resisting zinc-coated steels |
| PMCO.1-12 PRESS TYPE | 60 | 24" | .020-.125 | 180 - .032 | 2600 | 2, 4, 6 | Same as PMCO.1-11 plus: ordinary black & high tensile steels |
| PMCO.1-13 PRESS TYPE | 60 | 24" | .020-.125 | 180 - .032 | 2600 | 3, 4, 5, 6 | Same as PMCO.1-12 plus: some air-hardening & chrome-molybdenum steels |
| PMCR.1-3 ROCKER ARM | 60 | 24" | .020-.090 | 180 - .032 | 2600 | 1 | Same as PMCO.1-11 plus: Pickled Steels |
| P-1-R PORTABLE | 90 | * | .020-.080 | * | * | 1 | Same as PMCR.1-3 |
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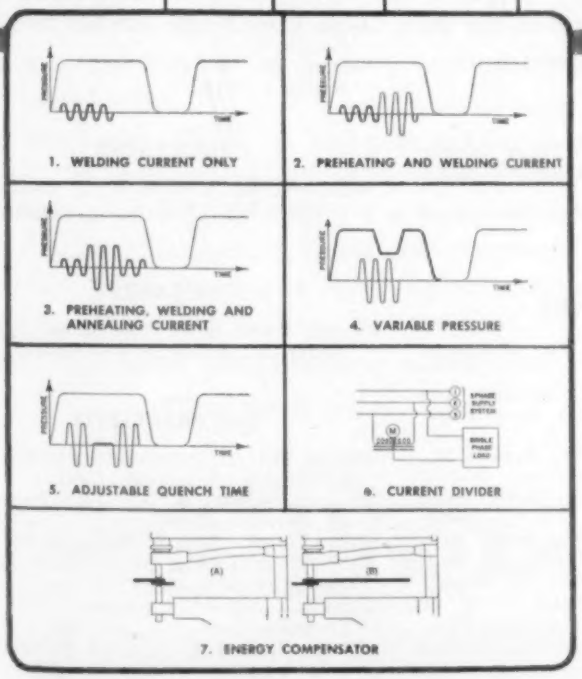
| PMCO.2-1 PRESS TYPE | 190 | 34" | .032-.250 | 80 - .064 | 4000 | 3, 4, 5, 6, 7 | |
| PMM.2-1 SEAM WELDER | 700 | 34" | .020-.064 | 400 - .040 | 2140 | 1 | Monel metals, low carbon & corrosion resisting steels |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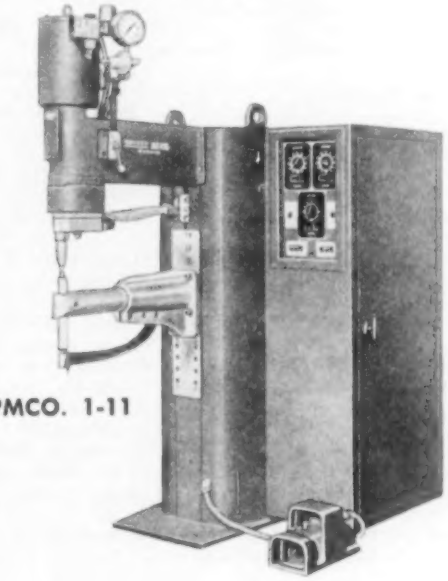

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**Faulkner, B. W.** (B), 31 Southern St., Chickasaw, Ala.
**Ratcliff, Clifford** (B), 206 Mohawk St., Mobile, Ala.
**Walker, Arnold** (B), c/o F. B. Walker & Sons, Pascagoula, Miss.

### NEW JERSEY

**Alexander, Harland E., Sr.** (C), 136 Orient Ave., Jersey City, N. J.
**Kreisel, Otto** (C), 59 Elmwood Terrace, Irvington, N. J.
**Polovitch, Michael** (C), 23 Wilson Terrace, Linden, N. J.
**Riel, Charles T.** (C), 57 Shaler Ave., Cliffside Pk., N. J.

### NEW YORK

**Brown, Harold I.** (C), c/o Kraus, 109–20—71st Rd., Forest Hills, L. I., N. Y.
**Esposito, Henry** (C), 116 Tyrconnell St., Massapequa, N. Y.
**Ferris, Harold C.** (C), Dover Plains, Dutchess Co., N. Y.
**Galvin, Patrick J.** (C), 159–55—102nd St., Howard Beach 14, L. I., N. Y.
**Heymann, Harry** (C), 632 Ocean Pkway., Brooklyn 30, N. Y.
**Isenberg, James D.** (C), 34–05—28th Ave., Astoria, L. I., N. Y.
**Jacoby, Joseph A. W.** (C), Rockland Gas Co., Inc., 40 Lawrence St., Spring Valley, N. Y.
**Migge, William P.** (C), 75 Maine Ave., Rockville Center, L. I., N. Y.

### NORTHWEST

**Bass, J. P.** (C), 95 Malcolm S. E., Minneapolis 14, Minn.
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**Krueger, Edward G.** (B), 6309 Wentworth Ave., So., Minneapolis 9, Minn.
**Kruger, Erwin J.** (B), 975 Seminole Ave., St. Paul 7, Minn.
**Nelson, Alvin C.** (B), 1178 Thomas Ave., St. Paul 4, Minn.
**Sullivan, H. E.** (C), 3251—35th Ave., So., Minneapolis, Minn.

### PEARL HARBOR

**Adams, Merle L.** (C), 301—6th St., Navy Housing, Honolulu, T. H.
**Berger, Emile F.** (C), 1207 Peterson Lane, Honolulu, T. H.
**Buckles, Ralph P.** (C), 500—16th St., Navy Housing, Honolulu 62, T. H.
**Card, Robert E.** (C), 320 Lewers Rd., Honolulu, T. H.
**Caroli, J. P.** (C), c/o Shop 26, Navy Yard, Pearl Harbor, T. H.
**Champagne, Armand J.** (C), A-8-555 Main St., Honolulu, T. H.
**Contrades, John, Jr.** (C), 490 Airport Rd., Honolulu, T. H.
**Di Tella, Angelo A.** (C), 2205 Waikolu Way, Honolulu 20, T. H.
**Duvall, William E.** (C), P-4 733—18th St., Navy Cantonment, Honolulu, T. H.
**Ellenberger, Kenneth E.** (C), 309 A. South Vineyard St., Honolulu 39, T. H.
**Ennis, Edward A.** (C), 1120 D Koko Head Ave., Honolulu, T. H.
**Faith, Earl N.** (C), 320 Lewers St., Honolulu 37, T. H.
**Funk, Roy A., Jr.** (C), 315 Ohua Ave., Honolulu, T. H.
**Guildig, Armund A.** (C), 2421 Ala Wai Blvd., Honolulu, T. H.
**Hanna, George H.** (C), 1323-D-Makiki St., Honolulu, T. H.
**Henry, Harold H.** (C), C-1-504—17th St., C. H. A. 3, Honolulu 62, T. H.
**Hill, Woodrow K.** (C), Welding Eng., Shop Supt. Office, Pearl Harbor, Honolulu, T. H.
**Ingram, Charles C.** (C), 513—8th St. N. H., Honolulu, T. H.
**Jarvis, Willie E.** (C), 624 Kapahulu Ave., Honolulu, T. H.
**La Francesca, Dick** (C), 2490 Kalakaua Ave., Honolulu 30, T. H.
**Lane, Rupert O.** (C), 3011 Makini St., Honolulu, T. H.
**Lauenborg, Howard A.** (C), 811 Lunalilo, Honolulu, T. H.
**Mills, George E.** (C), 913—8th Ave., Honolulu 47, T. H.
**Morgado, Arnold** (C), 2111 North King St., Honolulu, T. H.
**Morgareidge, Dea S.** (C), 247-C Beachwalk, Honolulu, T. H.
**Noftsinger, R. J.** (C), c/o Shop 26, Navy Yard, Pearl Harbor, T. H.
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**Petitt, James R.** (C), P. O. Box 203, C. H. A. 3, Honolulu 1, T. H.
**Pozenel, Joseph, Jr.** (C), B15 Room 1, C. H. A. 3, Honolulu, T. H.
**Preda, C. C.** (C), 1929-A Wilder Ave., Honolulu 24, T. H.
**Price, Howard W.** (C), 3454-B Pahoa Ave., Honolulu 32, T. H.
**Rowan, George C.** (C), 4211 Kapahula Ave., Honolulu, T. H.
**Shanley, Howard J.** (C), c/o Shop 26, Navy Yard, Pearl Harbor, T. H.
**Snodgrass, Ralph W.** (B), 1317-B 7th Ave., Honolulu, T. H.
**Studinger, Adam A.** (B), c/o Shop 26, Navy Yard, Pearl Harbor, T. H.
**Thomas, Wm. J.** (C), 438 B. Niu St., Honolulu, T. H.
**Tillman, John R.** (C), 4586 Aukai Ave., Honolulu, T. H.
**Vierra, Edward B.** (C), 3123 Kannasa St., Honolulu, T. H.
**Ward, Florn A.** (C), U. S. Navy Cantonment, Building 20, Room 13, Honolulu 6, T. H.
**Watson, James E.** (C), 1210 Palolo Ave., Honolulu, T. H.

### PHILADELPHIA

**Arndt, Harold W.** (C), 612 Woodcrest Ave., Ardmore, Pa.
**Barnes, A. Wayne** (C), Belmont Iron Wks., 2215 Washington Ave., Philadelphia 46, Pa.
**Becker, Karl H.** (C), 547 E. Vankirk St., Philadelphia 20, Pa.
**Brew, W. Robert** (C), 20 Beloit Ave., Audubon, N. J.
**Cass, Boyd E.** (C), Mayfair House, Lincoln & Johnson Drs., Philadelphia, Pa.
**Dietrich, G. Alfred** (C), 476 Roxborough Ave., Roxboro, Philadelphia 28, Pa.
**Ehly, Walter S.** (C), Belmont Iron Wks., 22nd & Washington Ave., Philadelphia 46, Pa.
**Erb, Lester D.** (C), 8 Rhode Island Ave., Erlton, N. J.
**Freebairn, Robert V.** (C), 7025 Gillespie St., Philadelphia, Pa.
**Gale, Smith C.** (C), 102 Carlisle Rd., Audubon, N. J.
**Hendricks, W. E.** (C), Belmont Iron Wks., 22nd & Washington Ave., Philadelphia 46, Pa.
**Hill, J. Howard** (C), 957 Ashland Ave., Eddystone, Pa.
**Letherbury, John B.** (C), 7028 Woolston Rd., Philadelphia 38, Pa.
**Lightfoot, Roy Clifford** (C), 2432 W. Oxford St., Philadelphia, Pa.
**Makim, Robert S.** (C), 1517 South Stanley St., Philadelphia, Pa.
**Messick, Howard R.** (C), Belmont Iron Wks., 2215 Washington Ave., Philadelphia 46, Pa.
**Michaelson, Irvin** (B), 7113 Lincoln Dr., Philadelphia 19, Pa.
**Miles, Herman** (C), 1314 E. 13th St., Eddystone, Pa.
**Morris, L. S.** (C), 708—14th Ave., Prospect Pk., Pa.
**Quinn, John J.** (C), Belmont Iron Wks., 2215 Washington Ave., Philadelphia 46, Pa.
**Ribbenhouse, Edwin M.** (C), 3345 Tilden St., Philadelphia 29, Pa.
**Samans, Walter** (B), Sun Oil Co., 1608 Walnut St., Philadelphia, Pa.
**Seiffert, Robert E.** (C), 31 City Ave., Bala-Cynwyd, Pa.
**Stahl, Harry H.** (C), c/o Belmont Iron Wks., 2215 Washington Ave., Philadelphia 46, Pa.
**Whitcomb, Frank S.** (C), 243 Rochelle Ave., Philadelphia, Pa.

### PITTSBURGH

**Pirkola, S. C.** (C), Apt. 7, Tamaqui Village, Vanport, Pa.
**Montgomery, Paul J.** (C), 1411 Scott St., Huntingdon, Pa.

### PUGET SOUND

**Brown, W. C.** (B), 3059 South 154th St., Seattle, Wash.
**Caldwell, William C.** (B), Rt. 1, Box 188, Spanaway, Wash.
**Downing, J. P.** (C), 2112—13th Ave., So. Seattle, Wash.
**Long, Victor R.** (B), 1328 No. 200th St., Seattle, Wash.
**Offner, W. W.** (B), 1615—2nd Ave., Seattle 1, Wash.

### ROCHESTER

**Campbell, E. S.** (C), E. S. Campbell Welding Wks., 6 East Ave., Caledonia, N. Y.

### ST. LOUIS

**Sutter, Oscar G.** (C), St. Louis County Water Co., Route 25, Chesterfield, Mo.

### SAN FRANCISCO

**Berner, Leo** (A), Joshua Hendy Iron Wks., Hendy Ave., Sunnyvale, Calif.
**Froines, William B.** (C), 1408 Fairview St., Berkeley, Calif.
**Sykes, Lieut. John J.** (C), c/o Pollock Stockton Shipbldg. Co., Stockton, Calif.
**Tarbox, Donald T.** (C), U. S. Naval Drydocks, c/o Shop 26, Hunters Point, San Francisco, Calif.
**Wright, Richard H.** (C), 3474 Parker Hill Rd., Santa Rosa, Calif.

### SOUTH TEXAS

**Callahan, V. L.** (B), International Minerals & Chem. Co., Magnesium Div., Box 1163, Austin, Tex.
**Crim, George Lee** (C), P. O. Box 1325, Port Arthur, Tex.

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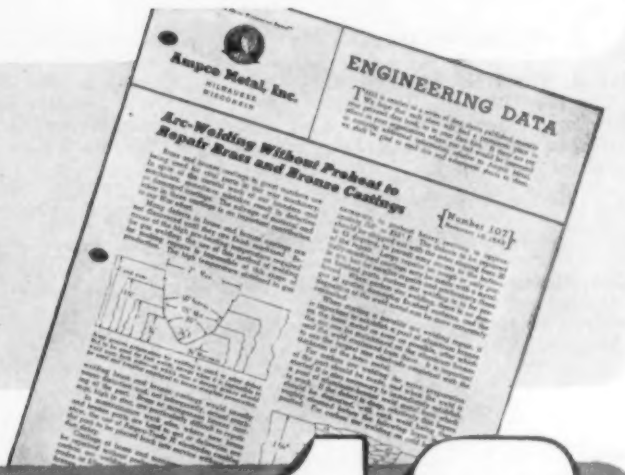
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{Number 107}

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*Gray Coating — Blue Tip*
General-purpose bronze welding rod for welding dissimilar metals, manganese bronze castings, brass sheets and plates, etc.

**Ampco-Trode 16**
*Gray Coating — Red Tip*

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For high-tensile welds requiring good ductility and subject to severe conditions of wear or corrosion.

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**Knapp, L. R.** (B), Sunflower Welding Wks., Claflin, Kan.
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**Kasmark, Joseph V.** (C), 115 N. Grand St., Lewiston, Pa.

NOT IN SECTIONS

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**Dickson, Raymond E.** (C), 486 Woodford St., Portland, Me.
**Duffy, Wm. J., S./Sgt.** (C), 1052 Eng. A. P. O. 713, c/o Postmaster, San Francisco, Calif.
**Kenniston, Fred R.** (C), 26 Farm Hill Rd., Cape Elizabeth 7, Me.
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**Lines, Robert Frederick** (B), 160 Morden Rd., Mitcham, Surrey, England.
**Skipper, Charles Wilburn, Sr.** (B), 40 East 54th St., Jacksonville 6, Fla.
**Smith, Paul R.** (C), 13 Montreal St., Portland, Me.
**Vanderhorst, Paul M.** (C), 3915 Granby St., Norfolk 8, Va.
**Young, Carl** (C), Kalamazoo Stove & Furnace Co., 500 Rochester Ave., Kalamazoo, Mich.

# Members Reclassified

During Month of January

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**McLellan, David S.** (from D to C), 36 Winchester St., Brookline, Mass.
**Neidick, Albert** (from D to C), 2 Riverside Dr., No. Reading, Mass.

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**Casserly, William J.** (from D to C), 7344 So. Paulina St., Chicago, Ill.

CONNECTICUT

**McCarthy, Erwin H.** (from D to C), 437 Kerema Ave., Devon, Conn.

LOUISIANA

**Woolman, E. G.** (from D to C), 4-1 Maplewood, Sulphur, La.

MILWAUKEE

**Loebel, Maurice G.** (from D to C), 1752A S. Pearl St., Milwaukee, Wis.

NEW JERSEY

**Comandatore, Joseph** (from D to C), Division Welding Co., 154 Broadway, Jersey City, N. J.
**Hoydich, Nicholas** (from D to C), 43 Brenner St., Newark, N. J.
**Lantz, Eric** (from D to C), 526 Broad Ave., Leonia, N. J.

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**Suber, Ralph C.** (from D to C), 16 Park Ave., Beacon, N. Y.
**Halonie, Victor S.** (from D to C), Como Station, St. Paul, Minn.
**Nash, James E.** (from D to C), 3016 Blaisdell Ave., Minneapolis, Minn.

PEARL HARBOR

**Woodling, David E.** (from C to B), 448-B Namahana St., Waikiki, Honolulu 37, T. H.

PHILADELPHIA

**Kuehner, Martin R.** (from D to C), 4211 E. Tudor St., Philadelphia, Pa.

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**Voss, Joe E.** (from D to C), 2045 South 8th St., Tacoma 6, Wash.

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**Eberle, Frank, Jr.** (from D to C), 309 N. Bryan, Houston, Tex.

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**Bennett, F. L.** (from D to C), 128 Eldorado St., Syracuse, N. Y.

YORK-CENTRAL PENNA.

**Barr, Robert** (from D to C), Box 115, Downington, Pa.
**Heisey, Paul B.** (from D to C), R. D. 1, Elizabethtown, Pa.

NOT IN SECTIONS

**Gibbs, Arthur E.** (from D to C), 3724 N. E. 21st Ave., Portland 12, Ore.
**Curls, Aaron Barnard** (from C to B), Food Machinery Corp., Lakeland, Fla.
**Zagata, Walter, Sgt. (32766281)** (from D to C), Service Battery, 303 Field Art, A. P. O. 445, Fort Leonard Wood, Mo.

## OBITUARY

### Jesse Jay Ricks

Jesse Jay Ricks, Chairman of the Board of Union Carbide and Carbon Corporation died at his home in Plandome, N. Y., on February 20, 1944, after a brief illness. He was 64 years of age.

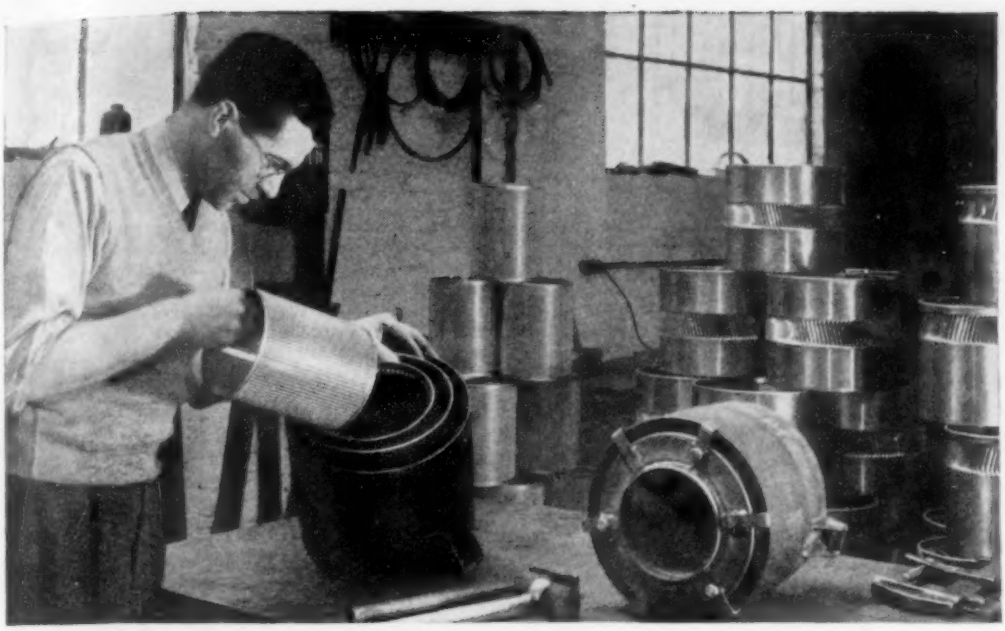
Mr. Ricks became Chairman of the Board of Union Carbide and Carbon Corporation in 1941. He had been President from October, 1925 to May of 1941. Nearly twenty years ago he instituted a liberal policy of research that has been in a large measure responsible for the growth of the numerous interests of the Corporation which he headed.

Mr. Ricks was born in Taylorville, Illinois in 1879, the son of the late James B. and Pammie Letitia Ricks.

He received his early education in the local public schools and was graduated from the University of Michigan with the degree of Bachelor of Philosophy in 1901. The Michigan Law School awarded him the degree of Bachelor of Laws in 1903. During his school years at Ann Arbor he was on the staff of the "Michigan Law Review."

After admission to the Bar of Illinois in 1903, he joined the law firm of Sears, Meagher and Whitney, Chicago. Later he became a partner in the firm of Meagher, Whitney, Ricks and Sullivan, which handled legal matters for Union Carbide Company. In 1917 when this company and several other important industrial companies joined to form Union Carbide and Carbon Corporation, Mr. Ricks went to New York City to help complete the legal arrangements. On completion of his work he joined the law department of the new Corporation, later becoming Chief Counsel.

In addition to his many important business activities, Mr. Ricks was for many years noted for his interest in music, in book collecting, and in natural history, particularly bird life. In this connection he was a member of the American Museum of Natural History, the American Forestry Association, Wilson Ornithological Society and the American Bibliophile Society.



*Inserting a welded, perforated Monel cylinder to complete a separator. Sixty of these units using 180 Monel cylinders are now in service in British supply cargo vessels built under supervision of the U. S. Maritime Commission.*

Redesign of boiler accessory in welded Monel

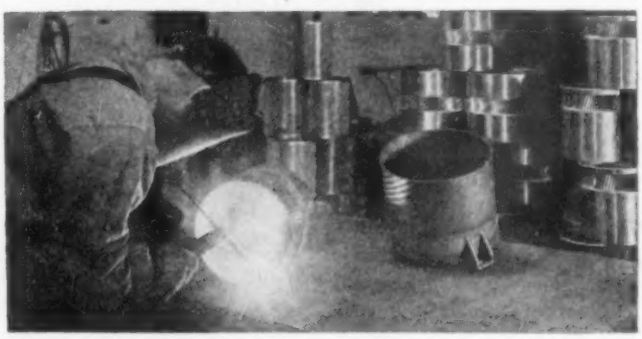
# REDUCED COST 30%, WEIGHT 50%

***Change from cast bronze to welded Monel sheets also increases life of Steam Separator***

The Dri-Steam Boiler Separator is a compact unit mounted inside of the boiler drum. Removing moisture and solids from outgoing steam, it assures dry, clean steam at boiler outlet under all operating conditions.

Some time ago the makers, Dri-Steam Products, Inc. of New York re-designed this unit with excellent results. Cost of the separator was cut one-third. Weight was reduced by one-half. In over two years of actual service not a single failure has been reported.

The change consisted of redesigning the separator to take separating elements made of Monel sheet instead of cast bronze. The bronze had a limited life, frequently as short as three months.



*Welding 14 gauge Monel cylinder for the Dri-Steam Boiler Drum Separator.*

Other materials were tried, but proved too difficult to work. Monel was finally adopted because it was found amenable to perforating, punching, and spot and electric welding . . . and its combined strength and resistance to corrosion assure freedom from trouble, and eliminate need for maintenance. The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.

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***Sheet...Strip...Rod...Tubing...Wire...Castings***

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